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U.S. Department of Transportation
Federal Aviation Administration
Specification

ARSR-4 RADAR SYSTEM

Library Use Only

DOCUMENT CONTROL CENTER

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TABLES

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APPENDICES

1.0 Scope.- The purpose of this document is to specify a three dimensional, all solid-state, unattended surveillance radar. This radar is being procured to replace the existing joint-use [United States Air Force (USAF) and Federal Aviation Administration (FAA)] search and height-finder radars (ARSR-1, -2, -3; AN/FPS-20/60 series and AN/FPS-6/90/116). It will provide three dimensional (range, azimuth and height) digital data on aircraft targets within a 250 nautical mile (nm) radius centered upon the radar at altitudes up to 100,000 feet (ft.) above Mean Sea Level (MSL) and -7 to +30 degree elevation angles. Separately controlled and programmable data ports shall be provided for the FAA Air Route Traffic Control Centers (ARTCC) and the USAF Sector Operations Control Centers (SOCC).

2.0 Applicable Documents.- The following specifications, standards, and other documentation form a part of this specification and are applicable to the extent specified herein, except FAA-G-2100e. FAA-G-2100e applies in its entirety as revised herein.

2.1 FAA Documents.-

2.1.1 FAA Specifications.-

FAA-E-2217	Digital Data Communications System
FAA-E-2319b	Air Traffic Control Beacon Interrogator
FAA-E-2679a	Common Digitizer - 2 (CD-2)
FAA-E-2716	Mode Select Beacon System (Mode S) Sensor
FAA-E-2751	Mode S Antenna Group, En Route Array
FAA-G-2100e	Electronic Equipment, General Requirements

2.1.2 FAA Standards.-

FAA-STD-012a	Paint Systems for Equipment
FAA-STD-019a	Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities
FAA-STD-020a	Transient Protection, Grounding, Bonding, and Shielding Requirements for Equipment
FAA-STD-024a	Preparation of Test and Evaluation Documents
NAS-MD-790	Maintenance Processor Subsystem to Remote Monitoring Subsystems and Remote Subsystem Concentrators

| NAS-MD-792 | Operational Requirements For The Remote Maintenance Monitoring System (RMMS) |
| NAS-MD-793 | Remote Maintenance Monitoring System Functional Requirements For The Remote Monitoring Subsystem (RMS) |

2.1.2.1 FAA Orders. -

| FAA Order 1010.51A | U.S. National Standard for the IFF Mark X (SIF)/ Air Traffic Control Radar Beacon System Characteristics |
| FAA Order 3910.3A | Radiation Health Hazards and Protection |

2.2 Military and Federal Publications. -

2.2.1 Military Specifications. -

MIL-C-15305E	Coils, Fixed and Variable, Radiofrequency, General Specification for
MIL-C-39010C	Coils, Fixed Radiofrequency, Molded, Established Reliability, General Specification for
MIL-F-15733G	Filters and Capacitors, Radio Frequency Interference, General Specification for
MIL-H-46855B	Human Engineering Requirements for Military Systems, Equipment and Facilities
MIL-HDBK-472	Maintainability Predictions
MIL-P-28809A	Printed Wiring Assemblies
MIL-S-19500G	Semiconductor Devices, General Specification for
MIL-T-27E	Transformers and Inductors (Audio, Power, and High Power Pulse) General Specification for
MIL-T-21038D	Transformers, Pulse, Low Power, General Specification for

2.2.2 Military Standards. -

MIL-STD-275E	Printed Wiring for Electronic Equipment
MIL-STD-454K	Standard General Requirements for Electronic Equipment
MIL-STD-461C	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-469	Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-STD-471A	Maintainability, Verification/Demonstration/ Evaluation
MIL-STD-721C	Definitions of Terms for Reliability and Maintainability
MIL-STD-781D	Reliability Testing For Engineering Development, Qualification, and Production
MIL-STD-785B	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810D	Environmental Test Methods and Engineering Guidelines
MIL-STD-883C	Test Methods and Procedures for Microelectronics
MIL-STD-1130B	Connection, Electrical, Solderless Wrapped
MIL-STD-1250	Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies
MIL-STD-1472C	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-1521B	Technical Reviews and Audits for Systems, Equipment, and Computer Software
MIL-STD-2076	Unit Under Test Compatibility with Automatic Test Equipment, General Requirements for

2.2.3 Federal Documents.-

AFR 80-18   DOD Engineering for Transportability

AFSC Design Hdbk 1-2   General Design Factors

AFSC Design Hdbk 1-11   Air Transportability

AFSC Pamphlet 800-27   Part Derating Guidelines

CSESD-11, I   Communications Security Equipment Specification
                     for Fill Devices, KYX-13, KYX-15, KOI-18 (U),
                     National Security Agency, (Confidential- COMSEC)

DOD AIMS 64-900D   Performance/Design and Qualification
                     Requirements, Mode 4 Input/Output Data,
                     KIT/KIR-1A /TSEC

DOD AIMS 65-1000B   Performance/Design and Qualification Requirements
                     Technical Standard for the ATCRBS/IFF/MARK XII
                     Electronic Identification System

DOD-STD-1686   Electrostatic Discharge Control Program for
                     Protection of Electrical and Electronic Parts,
                     Assemblies and Equipment

DOD-STD-2167   Defense System Software Development

NAVMAT P4855-1   Navy Power Supply Reliability, Design, and
                     Manufacturing Guidelines

NSA 85-2C   Performance and Interface Specification for
                     TSEC/KG84C, General Purpose Encryption Equipment
                     (GPEE)(U)(Confidential-COMSEC)

RADC-TR-82-172   RADC Thermal Guide for Reliability Engineers

Airworthiness Standards: Transport Category Airplanes, Fire Protection,
Compartment Interiors; Federal Aviation Regulations, Part 25.853(b)

Manual of Regulations and Procedures for Federal Radio Frequency
Management: Issued by National Telecommunications and Information
Administration (NTIA)

2.3 Other Publications. -

AC 70/7460-1   Advisory Circular; Obstruction Marking and Lighting

ANSI X3.4-86   Information Systems - Coded Character Sets -
                      7-Bit American National Standard Code for
                      Information Interchange (7-Bit ASCII)

ANSI X3.66-79   Advanced Data Communication Control Procedures
                      (ADCCP)

ASTM B224   Coppers, Classification of

ASTM G53-84   Standard Practice For Operating Light- and
                      Water-Exposure Apparatus (Fluorescent UV-
                      Condensation Type) for Exposure of
                      Nonmetallic Materials

EIA-RS-232D-87   Interface Between Data Terminal Equipment and
                      Data Circuit Termination Equipment Employing
                      Serial Binary Data Interchange

EIA-RS-422A-78   Electrical Characteristics of Balanced Voltage
                      Digital Interface Circuits

EIA-RS-530-87   High Speed 25 Position Interface For Data
                      Terminal Equipment Connector and Data Circuit -
                      Terminating Equipment

IEEE-STD-488-78   Digital Interface for Programmable Instrumentation

IEEE-STD-796-83   Microcomputer System Bus

Copies of this specification and other applicable FAA specifications,
standards, and drawings may be requested in writing from the Contracting
Officer at the following address: Federal Aviation Administration/ALG-340, 800
Independence Avenue, S.W., Washington, D.C. 20591. Requests should fully
identify material desired; e.g., specification, standard, and drawing numbers
and dates. Requests should cite the request for proposals or the contract
involved or other use to be made of the requested material.

Information on obtaining copies of federal specifications and standards may be
obtained from General Service Administration Offices in Atlanta, GA; Auburn,
WA; Boston, MA; Chicago IL; Denver, CO; Fort Worth, TX; Kansas City, MO; Los
Angeles, CA; New York, NY; and Washington, D.C.

Copies of the military specifications, standards, and ASTM publications may be
obtained by addressing the Commanding Officer, Naval Supply Depot, 5801 Tabor
Avenue, Philadelphia, Pennsylvania 19120.

The RADC Reports may be obtained from the National Technical Information
Service (NTIS), Springfield, VA 22161, telephone number 703-487-4650. Mail
requests should cite the RFP or contract for which the materials are needed.

Copies of Department Of Defense (DOD) Air Traffic Control Beacon Interrogator
Identification Friend or Foe Mark XII System (AIMS) specifications 65-1000B
and 64-900D can be obtained from the Director of Material Management/MMAM-
AIMS, Robins AFB, GA 31098.

Copies of National Fire Protection Association (NFPA) publications may be
obtained from the NFPA, Batterymarch Park, Quincy, MA 02269.

Copies of the American National Standards Institute (ANSI) publications can be
obtained from the ANSI, 1430 Broadway, New York, NY 10018.

Copies of Electronic Industries Association (EIA) documents can be obtained
from the EIA, 2001 Eye Street, N.W., Washington, D.C. 20006.

2.4 Precedence of Documents.- If the requirements of this specification or
subsidiary documents are in conflict, this specification shall have precedence
with the sole exception of FAA Order 1010.51A identified in 2.1.2.1. In the
event of conflict between FAA Order 1010.51A and this specification, FAA Order
1010.51A shall have precedence. In the event of conflicts between FAA
document(s) and military and federal document(s), FAA document(s) shall have
precedence.

2.5 Paragraph Referencing.- When paragraphs are referenced herein (whether
to other paragraphs in this specification or to other documents) all
subordinate paragraphs to those references shall apply.

3.0 Requirements. -

3.1 Summary of Equipment and Services to be Furnished by the Contractor. -

The contractor shall furnish and install the quantity of radars, Air Route Surveillance Radar - Model 4 (ARSR-4), and other equipment, materials, and services specified in the contract. Any unit or part, except for general purpose test equipment and common hand tools, necessary for operation and adjustment in accordance with the requirements of this specification shall be incorporated even though that unit or part may not be specifically provided for or described herein. All features required to meet performance requirements, such as shock mounting of particular Line Replaceable Units (LRUs) or assemblies, heat circulation by means of blowers, controls, indicator lamps, overload protection devices, meters, test points, interlocks, switches, etc., shall be incorporated even though the features may not be specifically provided for, or described herein. All facilities, parts, and hardware, including receptacles, connectors, cabling (wiring), adapters and outlets shall be incorporated to enable the units of the subsystem or system to be properly assembled, interconnected, installed, and maintained as required herein. Each subsystem and system shall be complete and in accordance with all specification requirements stated herein, including the radome. All equipment supplied by the contractor shall be of such a design that its operation is fully compatible with all External Interface Equipment's (EIE's) operation.

3.2 Not Used. -

3.3 Definitions. -

3.3.1 Principal Azimuth Plane. - The principal azimuth plane in antenna arrays refers to the antenna frame of reference, with the coordinates row (r) and column (c) that intersect at or about phase center. One of the principal planes is normal to c (with co-phase column elements) and passes through row r. When the antenna is in the upright position, this principal plane coincides with the local horizontal, and refers to the principal azimuth plane.

When the column elements of a planar array are given a phase differential, the principal azimuth plane transforms to a conic surface. The conical axis coincides with the c coordinates, and its included angle is commensurate with the phase differential.

Azimuth antenna patterns, that are taken in the principal azimuth plane of its transform conic surface, demonstrate an angular dependence on only the r coordinate illumination function. This follows since the phasing in the column elements remain unaltered anywhere in the principal azimuth plane. The c coordinate illumination function is therefore decoupled from the azimuth antenna patterns.

The principal azimuth plane of a reflecting antenna subsystem is a plane which includes the line of maximum radiation from the antenna, and an intersecting horizontal line which is normal to the line of maximum radiation. This definition applies to the elevation/scan angle of the antenna.

The principal azimuth plane is by definition identical in planar and cylindrical arrays.

3.3.2 Principal Elevation Plane.- Arrays with co-phase row elements have as the principal elevation plane, the plane normal to the row (r) and that includes column (c). This definition assumes that the rows are parallel to the local horizontal, thereby aligning the principal elevation plane parallel to the vertical plane.

This definition precludes cylindrical arrays, whose elements are phase tapered by design. Elevation plane pattern measurements taken of a cylindrical array will in general exhibit elevation angle dependence on both c and r illumination functions. However, the vertical plane will here be referred to as the principal elevation plane with regards to the elevation pattern measurements for all antenna arrays.

The principal elevation plane of a reflecting antenna subsystem is a vertical plane passing through the center of the reflector and including the line of maximum radiation.

3.3.3 Peak of Beam.- The peak of beam of the antenna is defined as the intersection of the principal azimuth plane with the principal elevation plane.

3.3.4 Nautical Mile.- One nautical mile (nm) equals 12.3586×10^{-6} seconds/radar mile. The speed of light equals 2.99710×10^{8} meters/second. Therefore, one nautical mile equals 6076.1091 feet.

3.3.5 High Sited Site.- The term "high sited site" (may also be referred to as "high site) refers to a site in which the focal point of the antenna is at 6,500 feet above Mean Sea Level (MSL).

3.3.6 Low Sited Site.- The term "low sited site" (may also be referred to as "low site") refers to a site in which the focal point of the antenna is at 350 feet above Mean Sea Level (MSL).

3.3.7 Reflectivity Factor (Z).- The reflectivity factor (Z) is defined as the summation over unit volume of the sixth power of the particle diameters for rainfall. For this specification $Z = 200 \, r^{1.6}$ (dBZ = 10 log Z) shall be used, where r is rainfall rate in millimeters/hour and Z is in mm^6/m^3 units.

3.3.8 Field Adjustable/Selectable.- An adjustment or selection of a parameter that can be made at both the site and from a remote location via RMMS.

3.3.9 Site Adjustable/Selectable.- An adjustment or selection of a parameter that can be made from the site only.

3.3.10 Line Replaceable Unit (LRU).- An LRU is the lowest unit (e.g., module, circuit card assembly, printed circuit card, antenna bearing, etc.) that will be replaced within the operating system during on-site maintenance activities. It is a separate installable, physical package which performs a single function or group of closely related functions.

3.3.11 Site Visit.- A site visit is defined as an entry into the area containing the ARSR-4 for the purpose of performing preventive or corrective maintenance.

3.3.12 Failure.- Failure is defined as the event, or inoperable state, in which any unit or part of a unit, software, or firmware does not, or would not, perform its intended function or capability.

3.4 System Performance Requirements.- The ARSR-4 shall simultaneously meet
all of the specified requirements. All ARSR-4 requirements will be evaluated
by the Government using the performance levels specified herein.

The ARSR-4 shall meet the target detection performance specified in Table 3-1
in the specified clutter environments and in the actual site clutter
environments at each ARSR-4 installation site. The radar system shall be
designed to achieve this target detection performance even if the clutter
environment where the radar is installed is less stringent than that
specified. If the clutter levels in range, azimuth, and elevation cells at a
radar site are more stringent than that specified, the contractor may only
degrade target detection performance in those cells where terrain, rain and
angel clutter levels exceed the values specified. However, this degradation
of target detection performance shall only be permitted in the range, azimuth,
and elevation cells where the contractor can prove to the Government that
these clutter values experienced exceed the specified levels. At no time
under any clutter environment shall the ARSR-4 system exceed the 194 false
reports requirement specified in paragraph 3.4.1.6. All specified target
detection performance and false report rates required in specified clutter,
actual site clutter, and in the clear shall be tested and verified at each and
every field installation site to ensure compliance of all the specified
detection performance requirements at the radar's operational installation
site environment.

The ARSR-4 shall be capable of determining range, azimuth and height data on
each target detected during each azimuth scan. It shall be capable of
detecting fixed wing and nonfixed wing aircraft with ground speeds from 25
knots to 3000 knots.

The scan period of the ARSR-4 shall be 12 seconds (5 revolutions per minute
[rpm]) +/-0.1 seconds as measured at any or all angles.

The ARSR-4 shall be capable of detecting and reporting aircraft targets to a
range of 250 nm and from the earth's surface as low as -7 degrees to a maximum
of +30 degrees in elevation and to a maximum height of 100,000 feet MSL (see
Figure 3-1) in accordance with Table 3-1.

The ARSR-4 shall be capable of being operated and maintained without permanent
on-site personnel. Scheduled on-site preventive maintenance shall be required
no more than once every 91 days.

Target overload conditions shall be handled in such a manner so as to
eliminate radar data of least importance first and radar data of most
importance last. The actual priority ranking shall be approved by the
Government.

3.4.1 Primary Radar Coverage.-

3.4.1.1 Search Coverage.- The ARSR-4 shall detect and report targets through 360 degrees in azimuth. The slant range coverage shall be from 5 to 250 nm and the elevation coverage shall be to 100,000 feet MSL and from -7 to +30 degrees with reference to a zero degree radar horizontal. Coverage at lookdown angles (+0.2 to -7 degrees) shall be site selectable. See Figure 3-1.

3.4.1.2 Search Detection Envelope.- The ARSR-4 system shall provide the target detection levels specified in Table 3-1 in the actual clutter environment encountered at any ARSR-4 field site. The clutter levels specified in Table 3-1 are the minimum levels in which the contractor's design shall be capable of providing the specified detection performance in clutter. Additionally, the contractor shall provide the target detection performance levels specified in Table 3-1 if the actual clutter levels experienced at a field site are greater than those specified herein. Target detection performance may be degraded in range, azimuth, and elevation cells where the specified terrain, rain, and angel clutter levels are exceeded only if the contractor proves to the Government that the clutter levels in those cells are exceeded. The footnotes to Table 3-1 shall be interpreted as ARSR-4 requirements in the same manner as any other requirement specified in this specification. The specified performance shall take into consideration the effects of all system loss factors, including atmospheric losses due to absorption and lens-effects.
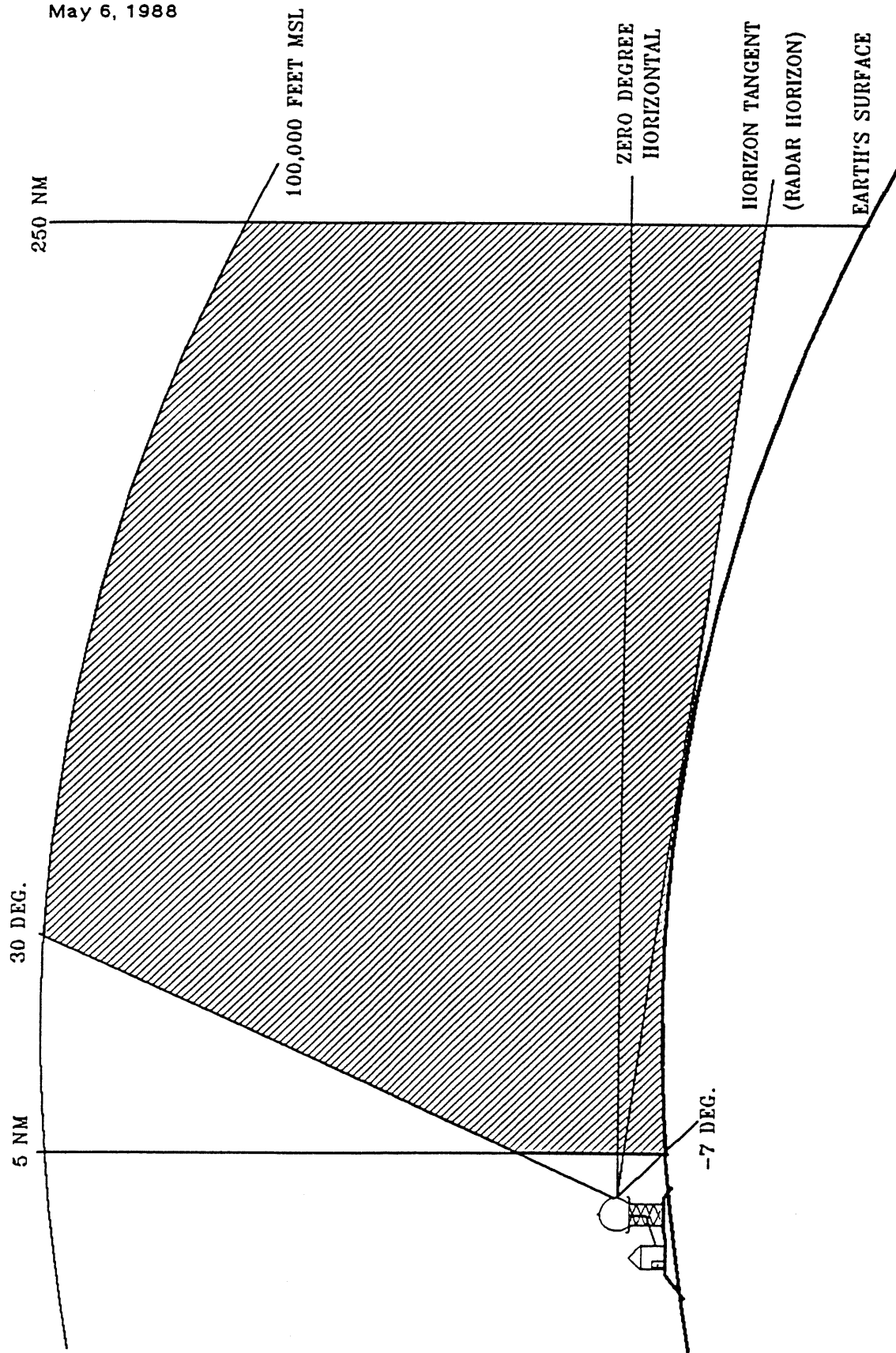
Figure 3-1, RADAR COVERAGE

TABLE 3-1 SYSTEM DETECTION PERFORMANCE

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)
Clear(B)	From the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL. (50,000 feet MSL for 0.1m² targets)	80 - Max V 0 - Max V 0 - Max V 0 - Max V	15 - 92 nm 15 - 165 nm 15 - 200 nm 15 - 250 nm	0.1m² 1.0m² 2.2m² 5.8m²	Pd ≥ 80 percent for 100 percent of the specified radial velocities.	
Sea State Five(A) Clutter reflectivity ≤ n_z + 3dB (Table A4)	From the surface(C) and above a line tangent to the horizon up to 100,000 feet MSL. (50,000 feet MSL for 0.1m² targets)	80 - Max V 20 - Max V	15 - 92 nm 15 - 99 nm	0.1m² 1.0m²	Pd ≥ 80 percent for 95 percent of the specified radial velocities.	Pd ≥ 80 percent for 99 percent of the specified radial velocities. At any velocity between 20 and 700 knots, the velocity response shall not fall more than 8 dB below the 20 - Max V knot mean level for at least one of the two scans for targets ≥1m²
Terrain(A) Wooded Hills = σ_o ≤ -17dB Mountains = σ_o ≤ -14dB Lowlands(E) = σ_o ≤ -24dB (θ_e = 5 degrees) σ_o ≤ -28dB (θ_e = 1 degree) σ_o ≤ -39dB (θ_e = 0.1 degree) Wooded Hills = σ_o ≤ -23dB Mountains = σ_o ≤ -20dB	From the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL.	20 - Max V 20 - Max V 20 - Max V	15 - 32 nm 15 - 99 nm 15 - 180 nm	1.0m² 1.0m² 2.2m²	Pd ≥ 80 percent for 95 percent of the specified radial velocities. This requirement does not apply to the spectral density 20 knot curve of Figure A3 for lowlands.	Pd ≥ 80 percent for 99 percent of the specified radial velocities. At any velocity between 20 and 700 knots, the velocity response shall not fall more than 8 dB below the 20 - Max V knot mean level for at least one of the two scans for the specified target sizes. This requirement does not apply to the spectral density 20 knot curve of Figure A3 for lowlands

TABLE 3-1 SYSTEM DETECTION PERFORMANCE (continued)

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)

Superclutter visibility for rain(G)

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)
Rain clutter(A,D) 1mm/hr rain plus Bright Band or cellular rain (4mm/hr (Tropical and middle latitude climatic conditions.)	From the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL.	10 - Max V 10 - Max V 10 - Max V	5 - 110 nm 5 - 160 nm 5 - 205 nm	1.0m² 2.2m² 5.8m²	Pd > 80 percent for 100 percent of the specified radial velocities	
Rain clutter(A,D) > 4mm/hr to (70mm/hr (Tropical and middle latitude climatic conditions)	From the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL.	10 - Max V 10 - Max V 10 - Max V	5 - 110 nm 5 - 160 nm 5 - 205 nm	Target size increases proportional to the increase in rain cross-section above 4mm/hr	Pd > 80 percent for 100 percent of the specified radial velocities	

Subclutter visibility for rain(G) (competing with clear(B) environments.)

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)
Rain clutter(A,D) ((10 mm/hr) (Tropical and middle latitude climatic conditions)	From the surface(C) and above a line tangent to the horizon up to 100,000 feet MSL.	20- Max V	5 - 92 nm	2.2m²	Pd > 80 percent for 70 percent of the specified radial velocities.	

TABLE 3-1 SYSTEM DETECTION PERFORMANCE (continued)

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)

ANOMALOUS PROPAGATION (LOW SITED SITE ONLY)

Ducting(F)

| Sea State Two(A) Clutter reflectivity $\leq n_x + 3dB$ (Table A4) | In a duct and from the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL. (50,000 feet MSL for 0.1m²) | 80-Max V 20-Max V 20-Max V 20-Max V | 15 - 92 nm 15 - 165 nm 15 - 200 nm 15 - 250 nm | 0.1m² 1.0m² 2.2m² 5.8m² | Pd ≥ 80 percent for 95 percent of the specified radial velocities. | Pd ≥ 80 percent for 99 percent of the specified radial velocities. At any velocity between 20 and 1700 knots, the velocity response shall not fall more than 8 dB below the 20-Max V knot mean level for at least one of the two scans for the specified target sizes. |

Through duct over water(F)

| Terrain Lowlands $\sigma_0 \leq -45dB$ | From the surface(C) and above a line tangent to the horizon, up to 100,000 feet MSL. | 20-Max V 20-Max V 20-Max V | 15 - 165 nm 15 - 200 nm 15 - 250 nm | 1.0m² 2.2m² 5.8m² | Pd ≥ 80 percent for 95 percent of the specified radial velocities. This requirement does not apply to the spectral density 20 knot curve of Figure A3 for lowlands. | Pd ≥ 80 percent for 99 percent of the specified radial velocities. Dim speeds notch depth shall not exceed 8dB for at least one of the two scans for the specified target sizes for radial velocities from 20 to 700 knots. This requirement does not apply to the 20 knot spectral density curve of Figure A3 for lowlands. |

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TABLE 3-1 SYSTEM DETECTION PERFORMANCE (continued)

Environmental Condition	Altitude Coverage	Radial(H) Velocity (Knots)	Applicable Range	Target Size	Detection(I) Probability (Single Scan)	Detection(I) Probability (Two consecutive scans)
Superclutter visibility for surface clutter (terrain and sea) for both normal and anomalous propagation and for rain competing with surface clutter.	As stated previously for each environmental condition.	0 - Max V	5 - 250 nm	18dB greater than the mean clutter to noise ratio in each resolution cell.	Pd $\geq$ 80 percent for 100 percent of the specified radial velocities	
Subclutter visibility for surface clutter (terrain and sea) for values greater than those specified previously. This applies to both normal and anomalous propagation.	As stated previously for each environmental condition.	As stated previously for each environmental condition.	As stated above for each environmental condition.	Target sizes associated with each Applicable Range increased proportional to the increase in clutter above the specified values up to a level equal to a $\sigma_0 = -14dB$	Pd $\geq$ 80 percent for 95 percent of the specified radial velocities in surface clutter environments. This requirement does not apply to the spectral density 20 knot curve of Figure A3 for lowlands.	Pd $\geq$ 80 percent for 99 percent of the specified radial velocities in surface clutter environments. This requirement does not apply to the spectral density 20 knot curve of Figure A3 for lowlands.

Footnotes to Table 3-1

A. Clutter is defined in the Clutter Model in Appendix A. Figures and Tables referenced in Table 3-1 can be found in Appendix A. The environments defined in Figure A1 of Appendix A are idealized sites for the purpose of evaluating performance in clutter. The ARSR-4 system shall have sufficient waveform and processing flexibility to adapt to the actual site clutter conditions. This adaptability shall provide the same performance specified in Table 3-1 for the specified clutter levels, altitudes, ranges, and target sizes at sites where the geographical mix of clutter differs as a function of range and azimuth from the idealized sites specified in Appendix A.

B. "Clear" is defined as those areas that satisfy all of the following conditions:

(1) Areas defined in Appendix A as dominated by thermal noise.

(2) Areas not containing clutter from antenna and waveform sidelobes which exceed thermal noise.

(3) Areas in the first (unambiguous) range interval that do not contain second- and third-time-around clutter.

C. "Surface" is defined as that portion of the Earth's surface between the ranges of 5 nm and the radar horizon (See Figure 3-1).

D. These superclutter and subclutter capabilities are specified quantitatively for rain alone. The processes used for both sub- and super-clutter visibility in rain shall also be available in combination with the clutter processing for surface clutter to address those situations where rain and surface clutter occur simultaneously in the same resolution cell (bimodal clutter). The system shall provide detection and velocity visibility at each field site in bimodal clutter situations commensurate with combining the processes used for detection in rain and surface (terrain and sea) clutter.

E. For grazing angles which fall at values other than the 5 degree, 1 degree and 0.1 degree values specified, the applicable σ_o shall be obtained by computing the 90th percentile levels using the formula in Table A1 of Appendix A.

Footnotes to Table 3-1 (continued)

F.   The detection requirements do not apply to the elevation gap
     between the top of the duct and the critical elevation angle.
     This angle should never exceed 1 degree and is generally less than
     0.5 degree.

G.   In the event that circular polarization is used to meet the
     requirement for detection in rain, the target sizes specified in
     Table 3-1 shall be reduced by 50 percent (e.g., 1.0m² decreases to
     0.5m²) for determining the Pd in rain.   This reflects the loss
     expected in backscatter energy from a given aircraft relative to
     linear polarization.   This loss of signal strength also exist in
     areas where rain does not exist, but need not be considered in
     meeting the detection requirements of Table 3-1 in these area.
     However, to minimize this loss, circular polarization shall be
     field selectable and adjustable as specified in 3.5.6.2.   If a
     technique other than circular polarization is used to meet the
     detection requirements in rain, any loss in detection resulting
     from the use of this technique must be included in meeting the
     performance specified in Table 3-1 for rain.   A loss of up to 3 dB
     in detection performance with respect to that specified in Table
     3-1 for other environments will be permitted.   However, to
     minimize such loss, if it occurs, the technique shall be field
     selectable and adjustable as described in 3.5.6.2.   The technique
     need not be selectable and adjustable, if all detection
     performance requirements specified in Table 3-1 are fully met
     using the technique.

H.   The maximum radial velocity (Max V) for use with this table is
     stratified by altitude as follows:

     <u>Maximum Velocity</u>   <u>Altitude</u>

     1,000 knots   0 to 10,000 ft. MSL
     1,500 knots   )10,000 to 30,000 ft. MSL
     3,000 knots   )30,000 to 100,000 ft. MSL

I.   The single scan detection probability applies to each and every
     range position throughout the specified detection volume and is
     not to be construed as detection average over a range interval.
     Similarly, the two consecutive scans detection probability applies
     at each and every two range positions as may be encountered by any
     target (3.4.1.5) on two consecutive scans.   The 10 knot spectral
     density curve in Appendix A, Figure A3a applies to sections of the
     table where lowlands clutter performance requirements are
     specified.

3.4.1.3 Height Coverage.- The ARSR-4 shall produce height reports on targets through 360 degrees in azimuth and from 5 to 250 nm in range. The elevation reporting coverage shall be from at least -1.0 (for high sited radars)/+0.2 (for low sited radars) to 20 degrees above the horizontal. Height of targets outside the -1.0/+0.2 to 20 degrees envelope (-7 to -1.0/+0.2 and +20 to +30 degrees) shall be reported and flagged as an invalid height report, but excused from the accuracy requirements stated in 3.4.1.9.3. The altitude coverage shall extend to 100,000 feet MSL.

3.4.1.4 Height Detection Envelope.- The height detection envelope shall be the same as the search detection envelope specified in 3.4.1.2.

3.4.1.5 Target Definition.- A target shall be defined as a manmade, unambiguous in range, flying vehicle possessing the following characteristics:

(a) Radar Cross Section (RCS): 0.1m² to 10,000m² (Swerling I), for linear polarization. (See footnote (g) of Table 3-1 for target sizes in the event circular polarization is used.)

(b) RCS versus Altitude versus Velocity (Knots):

RCS	Altitude	Velocity
0.1 to <1.0m² :	0 to 10,000 ft. MSL	80-1000 (Radial) 80-1000 (Ground)
	>10,000 to 30,000 ft. MSL	80-1500 (Radial) 80-1500 (Ground)
	>30,000 to 100,000 ft. MSL	80-3000 (Radial) 80-3000 (Ground)
1.0 to 10,000m² :	0 to 10,000 ft. MSL	0-1000 (Radial) 25-1000 (Ground)
	>10,000 to 30,000 ft. MSL	0-1500 (Radial) 25-1500 (Ground)
	>30,000 to 100,000 ft. MSL	0-3000 (Radial) 25-3000 (Ground)

(c) Dynamics: Maneuvers up to a Gravitational Force Factor (g) of seven (7g).

(d) Type aircraft: Fixed or nonfixed winged.

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3.4.1.6 False Reports.-   Averaged over ten scans, the number of false reports per scan at the output of the first function of the scan to scan correlation function (3.5.11) shall not exceed a total of 194 from all causes. A false report is defined as a transmission of a search message to the ARTCC/SOCC on any object other than a target (as defined in 3.4.1.5). This false report rate shall not be exceeded when the ARSR-4 is installed and operated at the installation sites. Additionally, the minimum clutter levels that the ARSR-4 shall be capable of providing this false report rate shall be those specified in Appendix A. If the clutter levels actually experienced at a site are greater than those specified in Appendix A, the ARSR-4 shall still maintain these specified false reports requirements. Additionally, false reports from individual causes shall not exceed the false report levels in the following list.

    (a) noise: 4

    (b) terrain and sea: 20

    (c) vehicular traffic and angels: 70

    (d) cellular precipitation: 100
           (or combined cellular and distributed precipitation)

    (e) distributed precipitation only: 20

The contractor shall not resort to blanking in order to maintain the false alarm rate requirements with the exception of target processing for vehicular traffic (3.5.11). The false report count shall be based on the first function output from the scan to scan correlation (3.5.11).

3.4.1.7 Performance in Clutter.- Appendix A describes the radar clutter environment for terrain clutter, sea clutter, rain clutter, angel clutter, ground vehicles and Anomalous Propagation (AP). Signal processing, search target extraction and scan to scan correlation shall address these clutter conditions. The contractor shall design his waveform(s) and antenna beamwidth to maximize interclutter visibility consistent with the overall specification requirements. Each ARSR-4 clutter processing function shall have full adaptability to the actual site clutter environmental conditions. The ARSR-4 shall be capable of providing clutter processing over the entire coverage volume (3.4.1.1) on each antenna scan, enabling the ARSR-4 to provide the specified target detection in clutter and false report rate anywhere in the coverage volume at the actual field site.

3.4.1.8 Radar Target Capacity.- The ARSR-4 will be operated in an air traffic environment with wide variations in aircraft population and the distribution of that population as indicated in the following list. The number of aircraft, not including false reports, may vary from zero to the maximum listed as a function of time or antenna azimuth or both. Beacon target capacity is specified in 3.4.2.4.

(a) Steady-state maximum: 800 aircraft returns within the primary radar coverage.

(b) Large sector peak: 50 aircraft returns in each of eight contiguous 11.25 degree sectors.

(c) Small sector peak: 20 aircraft returns in each of three contiguous 1.2 degree sectors.

(d) Azimuth peak: 60 aircraft returns aligned in an azimuth radial (could be in one elevation beam).

(e) Range distribution peak: 4 aircraft returns within 4.5 nm interval (excluding the 0 to 5 nm range interval from the site) not equally spaced.

3.4.1.9 Primary Radar Accuracy.- The accuracies specified in the following subparagraphs apply to all targets achieving a Pd of 0.8 or greater. During the frequency-hopping mode of operation (3.4.1.15.1), these accuracies do not apply to targets competing with clutter, but do apply to targets in the clear environment.

3.4.1.9.1 Range Accuracy.- Within the primary radar coverage to 250 nm, the ARSR-4 system shall provide single scan range surveillance information which is accurate to 1/16 nm [root-mean-squared (rms) values including all bias and jitter errors].

3.4.1.9.2 Azimuth Accuracy.- Within the primary radar coverage, the ARSR-4 shall provide single scan azimuth surveillance information which is accurate to 0.176 [2 azimuth change pulses (ACPs) (referenced in 3.5.3.2)] degree (rms values including all bias and jitter errors).

3.4.1.9.3 Height Accuracy.- Between 5 and 175 nm on a 2.2m² target, all height errors measured (on a single scan basis) in any 5 nm interval shall be within 3,000 feet rms (including all bias and jitter errors) of the target's true altitude. No height accuracy is required on height reporting outside the -1.0/+0.2 to +20 degree height detection envelope (3.4.1.3 and 3.4.1.4). At ranges beyond 175 nm the height accuracy shall not decay beyond that expected due to signal to noise ratio reduction and the angular spread.

3.4.1.10 **Primary Radar Resolution.** - During the frequency-hopping mode of operation (3.4.1.15.1), the following resolution requirements do not apply to targets competing with clutter, but do apply to targets in the clear environment.

3.4.1.10.1 **Range Resolution.** - Between 5 and 200 nm, the ARSR-4 shall be capable of resolving with a 90 percent probability, two 10m² RCS Swerling I targets separated by 1/8 nm in range and in the same azimuth and doppler (if used) resolution cell and within 2,000 feet in altitude of each other, while maintaining the specified range accuracy stated in 3.4.1.9.1 for those targets resolved.

3.4.1.10.2 **Azimuth Resolution.** - Both of the following conditions shall be met.

At 100 nm, the ARSR-4 shall be capable of resolving with 50 percent probability two 2.2m² RCS targets (T-38) separated by 1.5 degrees in azimuth in the same range and doppler (if used) resolution cell and within 2,000 feet in altitude of each other, while maintaining the specified azimuth accuracy stated in 3.4.1.9.2 on each target resolved. This resolution shall be met regardless of the relative phase of the signal from the two targets and while maintaining the specified azimuth accuracy stated in 3.4.1.9.2 for those targets resolved.

Between 5 and 200 nm, the ARSR-4 shall be capable of resolving with a 90 percent probability two 10m² RCS Swerling I targets separated by 2 degrees in azimuth and in the same range and doppler (if used) resolution cell and within 2,000 feet in altitude of each other. This resolution shall be met regardless of the relative phase of the signal from the two targets and while maintaining the specified azimuth accuracy stated in 3.4.1.9.2 for those targets resolved.

3.4.1.11 **Primary Radar Time Sidelobes.** - In the event that pulse compression is used, the time sidelobes separated by more than 1/8 nm from the peak response shall be at least 30 dB from the peak response of the pulse, including the effects of Sensitivity Time Contol (STC) over the undecoded pulse length(s).

3.4.1.12 **Primary Radar Data Update Rate.** - For each primary radar target detected, the range, azimuth, and height data shall be updated once per scan.

3.4.1.13 **Primary Radar Split Probability.** - The radar data shall be processed to yield no more than one output message per target per radar scan 99 percent of the time.

3.4.1.14 **System Data Delays.** - Data transmission delays as specified herein shall be attained under peak capacity conditions of 3.4.1.8 and 3.4.2.4, assuming the user configuration of paragraph 3.5.13(i), and are referenced to antenna azimuthal position relative to a target at antenna peak of beam. Targets with an RCS below 1m² are exempt from this requirement.

(a) When operating without Mode S, the ARSR-4, including Beacon Target Processor (BTP) data, overall data delay from antenna peak of beam to target report available at the input of the modems shall not exceed 1.5 second.

(b) When operating with Mode S, the ARSR-4 data delay from antenna peak of beam to the target report message sent to the Mode S system shall not exceed 0.35 seconds. The combined Mode S/ARSR-4 delay from the antenna peak of beam to target report transmission to the output port(s) shall not exceed 1.5 seconds. This shall be based on the Mode S processed data being sent to the editor function by the Mode S within 1.4 seconds after the antenna peak of beam on target. In the event that any Mode S data is not sent to the editor within 1.4 seconds, the report transmission delay shall be allowed to increase proportionately beyond the 1.5 seconds specified.

3.4.1.15 Primary Radar Frequency.- The radar shall be capable of operating and meeting the requirements specified herein over the entire frequency range of 1215 to 1400 MHz.

3.4.1.15.1 Tunability.- The ARSR-4 shall meet the criteria for tunability and for frequency spectrum capability stated in "Radar Spectrum Engineering Criteria" of the NTIA "Manual of Regulations and Procedures for Federal Radio Frequency Management". The radar shall normally operate on one or two assigned frequencies, but have the capability to change frequencies on a pulse-to-pulse basis (frequency-hopping) on at least 16 discrete frequencies distributed across the allotted frequency band. It shall also have the capability to determine the quietest of the 16 frequencies and transmit the next pulse on that quietest frequency. If time does not permit the quietest frequency selection on a pulse-to-pulse basis when using high Pulse Repetition frequencies (PRFs), then quietest frequency selection shall be on a batch-to-batch basis during those periods implementing the high PRFs. The automatic selection in any frequency-hopping mode shall be pseudo random, so as not to reduce the Pd by more than 10 percent of the unsquinted Pd due to missed azimuth if the radar beam squints in azimuth with changes in frequency. A pseudo-random batch mode which maintains clutter performance in the frequency-hopping operation shall also be provided. The selection of any or all discrete frequencies and all modes of frequency operation shall be field selectable in at least three separate azimuth adjustable sectors or over the entire 360 degrees. When there is nonsynchronous interference present that has power levels within the range specified in Appendix B of this specification, the Pd requirements do not apply when the ARSR-4 is in the frequency-hopping mode of operation. The frequencies for each system shall be provided by the Government 120 days prior to system delivery to the site.

3.4.1.15.2 Spectrum Engineering Criteria.- The requirements of the Manual of Regulations and Procedures for Federal Radio Frequency Management, Paragraph 5.3, as issued by the NTIA, MIL-STD-461 and MIL-STD-469 shall apply to the radar system (receive and transmit) described herein. In the event of any conflict between MIL-STD-461, MIL-STD-469, Manual of Regulations and Procedures for Federal Radio Frequency Management, and this specification, the most stringent requirement shall apply.

3.4.1.16 Primary Radar Jam Strobe Reporting.- The ARSR-4 shall provide the capability of reporting jam strobes as described in 3.5.8.

3.4.1.17 Weather Data Output.- A weather data processing function shall provide three threshold levels of weather contour data for air traffic control use and an analog weather data output for the RRWDS. Weather data shall be provided as specified herein and shall be reported out from the ARSR-4 in range and azimuth. Weather reports shall not be outputted statified in elevation.

3.4.1.18 Remote Monitoring Subsystem (RMS).- A subsystem of the Remote Maintenance Monitoring System (RMMS) shall be a functional part of the radar to enable remote monitoring and control of all necessary and applicable functions of the radar equipment. This subsystem is called the Remote Monitoring Subsystem (RMS). The RMS shall be embedded in the radar and shall have the following operational capabilities necessary for unattended operation:

    (a)   Monitor and alarm

    (b)   Remote control

    (c)   Performance certification

    (d)   Diagnostics

    (e)   Remote (field) adjustment and selection

3.4.2 Beacon System Performance.- The contractor shall provide a BTP that will meet the requirements in the following subparagraphs. The beacon system shall be capable of operation when the dedicated ARSR-4 primary radar is "off", or has failed in any form, allowing the beacon only target data to be provided to the users. With the exception of antenna rotation failure, no single failure shall cause the loss of both primary and beacon data. Additionally, Mode 4 equipment as described in 3.5.20 shall be provided. The contractor shall assume a beacon interlace sequence of Modes 3/A, 2, 3/A, C in meeting the requirements of the following subparagraphs. The ARSR-4 shall also be capable of providing the following requirements, via site adjustable features, in the event that the interlace sequence is altered as specified in 3.5.9.1.17.

3.4.2.1 Transponder Replies.- Aircraft transponders now in use have a variety of capabilities. A given transponder may respond to Mode 3/A only; Modes 3/A and C; Modes 3/A and 2; Modes 3/A, 2, and C; and Modes 3/A, 2, C, and 4. Future civil transponders may be required to respond to Modes 3/A and C at a minimum. A properly operating transponder on an aircraft which is within the beacon radar's normal coverage may, on occasion, fail to respond to a particular interrogation. Among the reasons for this characteristic of the beacon system are aircraft maneuvers, transponder dead time because of another interrogation, and transponder lockout because of an excessive number of interrogations. These effects cause the probability of an aircraft reply to a given interrogation to be less than unity. This probability is termed the round reliability and shall be assumed to be 0.76 at the input to the BTP for all performance requirements. Round reliability shall refer only to complete reply trains (24 μsec), and the missing replies shall be assumed to be uniformly distributed within each aircraft's sequence of replies.

3.4.2.2 ATCRBS Performance.- The Mark X [Selective Identification Feature (SIF)] Beacon System shall meet the requirements for beacon system performance as stated in this specification, DOD AIMS 65-1000B and DOT FAA Order 1010.51A. In the event of conflict among these specifications, the order of precedence shall be: DOT FAA Order 1010.51A, DOD AIMS 65-1000B, this specification. The Mark XII component of the beacon system shall meet the requirements included in DOD AIMS 65-1000B and those stated herein.

3.4.2.3 Probability of Detection (Pd).- Based on the interlace sequence specified in 3.5.9.1.17, the minimum acceptable Pd shall be as follows (subject to the false report criteria specified in 3.4.2.11):

Interrogations Per Primary Mode	Primary Mode Only Responding	Primary And One Secondary Mode Responding	All Modes Responding
4	not applicable	0.45	0.90
6	0.70	0.84	0.97
8	0.90	0.95	0.99
11	0.97	0.985	0.995
15	0.99	0.995	0.998
23	0.995	0.997	0.999

NOTE: Unless otherwise specified, these requirements shall be met over the full range of the system.

3.4.2.4 Capacity.- The beacon subsystem of the ARSR-4, including the Mode 4 processor, shall provide data messages consisting of the following:

(a) A peak of at least 800 beacon targets per scan.

(b) A peak of at least 400 beacon targets in a 90 degree sector.

(c) A short term peak of at least 20 beacon targets in each of three contiguous 1.2 degree sectors.

(d) A sweep [one Pulse Repetition Time (PRT)] peak of 60 beacon targets in a single beacon radar sweep, not including 30 replies from fruit.

(e) A range distribution peak of 4 beacon targets within a 4.5 nm interval (excluding 0 to 5 nm range interval from the site), not equally spaced.

3.4.2.5 Range Resolution.- When two or more beacon targets are at the same azimuth but separated by any range in excess of 0.7 μsec (344 feet), each target shall be detected and reported without its range and azimuth accuracies being degraded. In addition, these target reports shall be subject to the same split rate limits specified in 3.4.2.9. The codes of the targets shall be validated and accurate (in accordance with 3.4.2.10) whenever the range separation of the targets are such that their code and/or framing pulse positions overlap (at the 50 percent amplitude points) by 90 nanoseconds or less.

3.4.2.6 Azimuth Resolution.- At least 95 percent of the time, the BTP shall resolve two detected, stationary and identical targets which are within 0.0576 nm of each other in slant range and which are separated by an absence of beacon replies (with decoded ranges which are within that 0.0576 nm interval) for 18 beacon radar PRTs. Two detected 11 hit-per-mode, noninterferring, stationary or moving targets which are within 0.05 nm of each other in slant range and have at least one distinguishing characteristic shall be resolved at least 99.5 percent of the time. This requirement shall apply up to and including the condition of contiguousness (adjacent in azimuth with no intervening beacon radar PRTs). Distinguishing characteristics shall include different Mode 2 or Mode 3/A codes (including X pulses) and Mode C altitudes that differ by more than 100 feet.

3.4.2.7 Range Accuracy.- The BTP shall report at least 98 percent of all detected stationary targets at their correct slant ranges, plus or minus 1/32 nm. At least 95 percent of all moving targets with radial velocities of 700 knots or less shall be reported at their correct (average) slant range, plus or minus 1/16 nm.

3.4.2.8 Azimuth Accuracy.- The BTP shall report at least 80 percent of all detected stationary targets at their correct azimuths, plus or minus 0.176 degree, when the associated beacon radar is interrogating at ten times per degree of the antenna's rotation.

3.4.2.9 Split Reports.- The BTP shall not generate more than one beacon target report 99.5 percent of the time from a single aircraft's beacon reply sequence which is in response to interrogations from the associated beacon radar. This shall apply to any aircraft with a velocity (in any direction) of 3,000 knots or less even if the transponder's reply jitters in time by as much as 250 nanoseconds about its nominal range, providing that it has a discrete Mode 3/A code. For aircraft without the discrete Mode 3/A capability, no more than 1.0 percent of their reports shall be split reports.

3.4.2.10 Code Validation and Accuracy.- The BTP shall validate (3.5.9.1.8) the beacon code information as contained in the aircraft's reply for Modes 2, 3/A, and C [including Special Position Identification (SPI) and X pulses] at least 95 percent of the time when the number of actual hits received per mode is 11 or greater. When the actual number of hits per mode is 15 or more, the codes shall be validated at least 98 percent of the time. Validation of incorrect codes (due to fruit or other causes) shall occur less than 1.0 percent of the time. The validated codes shall be accurate at least 99 times out of 100.

3.4.2.11 False Reports.- The BTP shall produce no more than four false target reports per scan. This is an overall requirement and shall be met in the steady-state fruit condition of 3.4.2.12 herein, with any or all target conditions permitted herein, other than a mix of aircraft in which the number of nondiscrete Mode 3/A aircraft exceeds 30 percent of the total of beacon-equipped aircraft. In addition, the BTP shall detect and report civil emergency (Mode 3/A codes 7500, 7600, and 7700) and military emergency (four code trains in trail) in a manner so that no more than one false emergency report is reported per 48 hours, averaged over a 30-day period during these same conditions.

3.4.2.12 Fruit Rates.- The aircraft's beacon transponder often radiates a reply in response to an interrogation from another ground or airborne beacon radar interrogator. These fruit replies are not in response to the local beacon radar's interrogations and, hence, can be a major source of interference with the desired replies. Further, the fruit replies can arrive at any antenna azimuth via the beacon antenna's sidelobes. They can also arrive at any range because, generally, they are asynchronous with respect to the beacon radar. The number of fruit replies may vary from zero to the maximums listed below as a function of time or antenna azimuth or both with a random distribution in range and a uniform distribution in azimuth.

    (a)   Steady-state maximum: 20,000 non-Mode 4 fruit replies per second.

    (b)   180 degrees sector peak: 40,000 non-Mode 4 fruit replies per second.

    (c)   Mode 4 fruit rate: 30,000 Mode 4 fruit replies per second.

3.4.2.13 Target Processor.- The BTP shall meet the above requirements for beacon target returns consisting of replies with the specified round reliability of 0.76 from a transponder with capabilities in Modes 2, 3/A, and C which is in the presence of the fruit density specified in the table below. The BTP shall use all replies from the beacon target, including Modes 3/A, 2 and C replies, in any combination, in the target detection process. The detection modes shall be site selectable, enabling target detection to be based on any beacon mode, or modes, recieved such as Modes 3/A, 2, or C; or any combination thereof. The fruit rates in the following table shall be used to establish the beacon performance specified in the applicable paragraph. At least eight of the 14 possible information code bits shall be set in each of the fruit replies. Multipath affects will not be considered in meeting these performance requirements.

Beacon Performance Requirement Paragraph	Applicable Fruit Rate Description Paragraph
3.4.2.3	3.4.2.12(a)
3.4.2.5	3.4.2.12(a)
3.4.2.6	No Fruit Rate At All
3.4.2.7	3.4.2.12(b)
3.4.2.8	3.4.2.12(b)
3.4.2.9	3.4.2.12(b)
3.4.2.10	3.4.2.12(a)
3.4.2.11	3.4.2.12(a)
Mode 4 performance	3.4.2.12(c)

3.4.2.14 Beacon Radar Equipment.- The BTP shall operate correctly with any of the following beacon radar equipments:

(a)   ATCBI-5 Beacon Interrogator

(b)   FA-9409 Beacon Test Set

(c)   Radar Beacon Performance Monitor (RBPM)

(d)   Mode S (when in the backup mode of operation specified in 3.5.18.6)

(e)   Mode 4 Computer (KIR-1B or KIR-1C) and Interface Device (KG-84C)

3.4.2.15 Mode 3/A and Mode C Mapping.- It shall be possible to blank targets in 24 range and azimuth sectors (5 nm and 5 degree increments). Targets reporting with Mode 3/A and Mode C replies are deleted from the USAF message data in those azimuth sectors; however, those targets shall not be deleted from the FAA message data. Emergencies (7500, 7600 and 7700) will not be deleted.

3.4.3 Availability/Reliability.- The availability/reliability requirements apply to the entire ARSR-4 system (all Contractor Furnished Equipment (CFE) delivered to the field site) furnished by the contractor and excludes primary power and EIE.

3.4.3.1 Reliability Requirements.- The reliability shall be stated in terms of specified Mean-Time-Between-Critical Failure (MTBCF) (Mission Reliability) and Mean-Time-Between-Failure (MTBF) (Basic Reliability) in hours. The equipment configuration, reliability models, and reliability requirements for individual equipments or groups of equipments shall be determined and apportioned so that the reliability requirements specified below are satisfied:

(a)   The failure of any LRU shall not affect the performance of any other LRU.

(b)   With the exception of the antenna rotation interruption (3.4.3.1.1 unscheduled, 3.4.4.1 scheduled), no single ARSR-4 failure shall result in degradation or loss of both search and beacon data.

(c)   Provision of power to LRUs or removal of power from LRUs shall not affect the performance of other LRUs.

(d)   The equipment shall be selected so that it meets the specified and apportioned reliability requirements while also meeting the specified performance requirements at minimum life cycle costs.

3.4.3.1.1 Mission Reliability.- The ARSR-4 shall achieve a mission MTBCF of 1500 hours under the worse case environmental conditions specified herein. MTBCF is defined as the total ARSR-4 uptime divided by the number of critical hardware, software, and firmware failures that degrade Full Mission Capability (FMC). Failures due to incorrect instructions in the ARSR-4 technical documentation shall also be counted as relevant failures. FMC is that level of performance which allows the ARSR-4 to perform its mission within all the requirements of this specification including the Local Display Console (LDC), BTP, RMS, Built In Test Equipment (BITE), Mode 4, and radome. The RMS and radome must also meet, by themselves, the reliability requirements of 3.5.15.8.9 and 3.4.3.1.5 respectively. Errors/failures shall not be counted in the MTBCF calculations if the system performance is fully recovered within 100 msec of the initial fault alarm (3.5.15.8.8.1.1). In addition to the . above requirement of which the antenna is included, critical failures of any ARSR-4 hardware or software, or both (whether a part of the antenna or not) that result in the antenna rotation being interrupted as a direct result of the failure or in order to correct it, or both, shall have a MTBCF equal to or greater than 8766 hours. The MTBCF requirement is to be met under the maintainability requirements specified in 3.4.4.

3.4.3.1.2 Basic Reliability.- The ARSR-4 shall achieve a series configuration Mean-Time-Between-Failure; as determined by the reliability modeling, allocation and prediction specified in the ARSR-4 Statement Of Work (SOW); that will provide the specified MTBCF and operation availability within the specified allowable site visits (3.4.4.1.1) under the worse case environmental conditions specified herein. However, in no case shall the series configuration MTBF be less than 100 hours. The series configuration MTBF is defined as the total ARSR-4 uptime (not including EIE) divided by the total number of hardware, software, and firmware failures that require corrective maintenance action. Failures due to incorrect instructions in the ARSR-4 technical documentation shall also be counted as relevant failures.

3.4.3.1.3 Reliability Design Requirements.- Design criteria and guidelines shall be developed by the contractor for use by ARSR-4 designers as a means of achieving the required levels of reliability requirements for the ARSR-4 and shall include the following:

    (a)   The ARSR-4 shall automatically protect each major assembly, LRU, and subsystem from failures induced by improper operation or failure of any other ARSR-4 assembly, LRU or subsystem, or any external device connected to the ARSR-4 or communicating with it.

(b) Error detection circuitry shall be implemented in processors, memories and their interconnections such that the estimated mean time between errors not detected within the computer subsystem is greater than 20,000 hours. The ARSR-4 shall also have the capability to detect double memory errors, and detect and correct single memory errors for each Random Access Memory (RAM) memory location that stores executable code. Digital messages sent between subsystems shall conform to a standard protocol (e.g., ADCCP), and their integrity shall be protected by byte parity encoding or better techniques.

(c) The error detection and recovery procedures shall be such that erroneous data produced directly or indirectly as a result of detected errors shall not leave the computer subsystem.

(d) The primary copy of the system's software instructions and constant data resident in memory shall be protected from being accidentally overwritten. If normal system operation or recovery procedures require the copying of such data, all such copies shall be checked against the original by direct comparison or by other equally effective means.

(e) The ARSR-4 design shall permit detailed fault diagnosis (3.5.15), replacement of any of its LRUs mounted in nonrotating equipment, and verification of proper operation after repair, without degradation or disruption of the ARSR-4's normal service.

(f) Recovery procedures shall be implemented such that any noncritical failure results in the reconfiguration of the system as necessary to achieve correct operation at full capacity. Recovery procedures shall be such as to preserve critical surveillance data and any other critical information which cannot be reproduced by normal ARSR-4 operation within the recovery time. (This shall be true even in the case of memory failure.) The maximum time to complete such reconfiguration shall be 100 msec. The reconfiguration time shall be measured from the time of the initial fault alarm (3.5.15.8.8.1.1) to the time that good data is available at the outputs of the ARSR-4 system.

(g) Failure detection shall be performed on units regardless of their state, i.e. active (on-line) or backup (off-line). In the case of failure of a redundant off-line unit, action shall be taken to make that unit unavailable to the system within 100 msec following verification of the alarm (3.5.15.8.8.1.1). In the case of failure of an on-line unit that has redundant back-up, the recovery action shall make that on-line failed unit unavailable and restore the system to full performance within 100 msec of the initial fault alarm.

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    (h)   The ARSR-4 shall allow switching of input and output interfaces to accommodate the use of redundant units in related external subsystems and systems where available.

    (i)   Notification of the failure of any unit shall be available at the RMS output within the time period defined in 3.5.15.8.8.1 and 3.5.15.8.8.1.1.

    (j)   The ARSR-4 shall meet the requirements of 3.6 in the event of partial or complete loss of line voltages.

3.4.3.1.3.1 Thermal Management and Derating.- Thermal management (design, analysis, and verification) shall be performed by the contractor such that the reliability quantitative requirements are assured. RADC-TR-82-172 shall be used as a guide. Derating criteria shall be established for each design such that all parts used in the ARSR-4 are derated to achieve reliability requirements. As a minimum, Level 3 of AFSC Pamphlet 800-27 shall be used for this design.

3.4.3.1.4 Reliability Definitions.- Reliability terms shall be defined in accordance with MIL-STD-721 and MIL-STD-781 unless specifically modified herein. In the event of conflicts of interpretation, the definitions contained herein shall have precedence, followed by the "Definitions" and "Failures Categories" requirements of MIL-STD-781 and MIL-STD-721 in that order.

3.4.3.1.5 Radome Reliability.- The MTBCF of the radome shell shall be a minimum of 175,200 hours. The radome shell MTBCF does not include factors that are external to the radome shell such as ancillary equipment failure. The lightning protection subsystem and obstruction lighting subsystem shall have an MTBCF commensurate with the requirements of FAA-STD-019 and AC 70/7460-1. Redundant obstruction lighting shall be used at all sites in accordance with AC 70/7460-1.

3.4.3.2 Availability.- The availability of the ARSR-4 shall be consistent with the requirements presented herein and with the reliability and maintainability requirements of 3.4.3 and 3.4.4 , respectively. In computing availability full allowance shall be given to the routine employment of redundancy, excess capacity, and backup modes of operation to maintain continuity of system performance. Switch-over time for redundant units must meet the requirements of 3.4.3.1.3.

The ARSR-4 shall provide an Operational Availability (A_o) of at least 0.99742. The operational availability (A_o) of the ARSR-4 is defined as the probable fraction of total time, on a year-round basis, that the radar system will be found in an "up" condition. Therefore, the A_o is:

$$A_o = \frac{(\text{Total Time} - \text{Total Downtime})}{\text{Total Time}}$$

This definition applies to the combined corrective and preventive maintenance for the ARSR-4 radar system and includes response time (3.4.4.1), but specifically excludes site equipment extraneous to the radar, e.g., prime power and EIE. The availability requirements shall be met in conjunction with the maintainability requirements of 3.4.4.

3.4.4 Maintainability.-

3.4.4.1 Maintainability Quantitative Requirements.- The ARSR-4 System shall be designed to achieve a mean time to repair (MTTR) to the LRU level of no greater than 30 minutes and a maximum-corrective-maintenance-time ($M_{max}(\phi)$) of not greater than 90 minutes at the 95th percentile for on-equipment maintenance (MTTR and $M_{max}(\phi)$ are defined in MIL-Handbook 472). The Mean-Time-To-Restore-System (MTTRS) shall not exceed 30 minutes. The bearing(s) and gear(s) in the pedestal shall be replaceable at the site in a maximum time of four hours at the 99th percentile.

3.4.4.1.1 Corrective and Preventive Maintenance.- The ARSR-4 system shall require no more than 10 site visits per year for all corrective (non-critical failures) and preventive maintenance combined (includes both scheduled and unscheduled maintenance), in addition to the site visits required to correct critical failures. During the visit to correct critical failures, other maintenance (corrective and preventive) can be performed. The Operational Availability (A_o) shall be based on a response time (time from fault indication by the RMS to arrival of a technician on site) of 2 hours for critical failures. The response time for all other site visits shall be established by the contractor, but in no case be less than 48 hours. No more than 4 of the 10 site visits specified above shall require an outage. Corrective or preventive maintenance, or both, (other than for critical failures) that will result in an outage of the ARSR-4 system must be scheduled (at least one week advance notice), shall be performed no more frequently than every 91 days, and shall not exceed 2 hours outage per visit at the 90th

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percentile or six hours per visit at the 99th percentile. Thus, the total of all outages, in addition to those required for critical failures, shall not exceed 8 hours per year at the 90th percentile. The maximum scheduled downtime per year for maintenance actions on any ARSR-4 hardware or software, or both (whether a part of the antenna or not), that result in the antenna rotation being interrupted shall be no greater than 5 hours per year. Off-site repair of failed LRUs, which includes isolation and repair to the part level, shall have a MTTR (sometimes referred to as mean bench repair time) of no greater than one hour, using the support and test equipment determined by the logistic support analysis specified in the SOW. Site visits for the above mentioned two hour scheduled outages shall not require more than three persons to perform the corrective or preventive maintenance, or both. Except for these visits for the two hour scheduled outages, visits to perform corrective maintenance for critical failures, corrective maintenance for noncritical failures, preventive maintenance, or any combination of these maintenance actions shall only require one person. Preventive maintenance shall be required no more frequently than once every 91 days and shall require no more than a total of 25 labor hours per year. The maximum labor hours for the combination of on-site corrective and preventive maintenance shall not exceed 50 hours per year, excluding travel time.

3.4.4.2 Maintenance Actions.- It shall be possible to perform corrective or preventive maintenance, or both, on any LRU or several LRUs without degrading the performance of other units.

3.4.4.3 Maintainability Design.- The design of the ARSR-4 System shall provide modularity, easy accessibility, built-in-test (BIT) and other maintainability features to provide installation simplicity, ease of maintenance and the attainment of the maintainability requirements (both corrective and preventive). LRUs such as printed circuit boards or assemblies shall be replaceable without cutting or unsoldering connections. All plug in LRUs shall be mechanically keyed/coded for correct insertion.

3.4.4.4 Testability.- The contractor shall partition the ARSR-4 system to achieve the fault isolation requirements specified herein. Each LRU shall have sufficient test points for the measurement or stimulus of internal circuit nodes to achieve the capability of detecting 100 percent of all permanent failures at the site. Automatic monitoring and diagnostic capabilities shall be provided to show the ARSR-4 status (operable, inoperable, degraded) and to detect at least 98 percent of all failures and correctly isolate at least 99.9 percent of all detected failure faults to a group of no greater than 8 LRUs, 95 percent of all detected failure faults to a group of no greater than three LRUs and 85 percent of all detected failure faults to no greater than one LRU. False reporting of failures shall not occur more frequently than once per year. BIT shall report the occurrence of each detected failure to the RMS within the time period defined by 3.5.15.8.8.1 and 3.5.15.8.8.1.1. Automatic fault isolation may require remote manual initiation but shall be considered terminated when human interpretation of fault codes, fault signals, fault tree, meter readings, or similar aids is required to continue the isolation procedure. BIT shall report the results of fault isolation to the RMS after completion of the automatic diagnostic process as specified in 3.5.15.8.6 (b).

3.4.5 Useful Life.- The ARSR-4 shall have a useful life of at least 20 years. Any nonconsumable configuration items and units produced for the ARSR-4 shall be designed to function properly for the 20 year period under mission operating conditions for 24 hours per day, seven days per week with downtime for corrective and preventive maintenance as defined for reliability, maintainability and availability requirements in this document.

3.4.6 Environmental Conditions.- All equipment shall meet the specified performance requirements in the natural and induced environments described below. Equipments shall be designed and constructed to meet the service condition requirements of FAA-G-2100 as to storage and exposure in both operating and nonoperating configuration except as specified herein.

3.4.6.1 Climatological.-

3.4.6.1.1 Ambient Temperature.- Equipment to be installed inside fixed facilities shall be designed and constructed to operate within specified performance at indoor operating ambient temperature up to 50 degrees C (Celsius) and down to -10 degrees C.

Equipments to be installed and operated in the external environment and in the radome shall be designed to be capable of specified performance under the combined effects of temperature, solar loading and equipment heat dissipation. The thermal design shall be based on an ambient temperature external to the radome of -50 degrees C to +50 degrees C plus a solar radiation of 1150 Watts per m² for six continuous hours.

3.4.6.1.2 Relative Humidity.- The relative humidity to be used in the design and construction of the ARSR-4 shall be as specified in FAA-G-2100.

3.4.6.1.3 Altitude.- All ARSR-4 equipment shall be designed and constructed for storage and exposure at altitudes up to 36,000 feet MSL and for operation in altitudes up to 10,000 feet MSL without pressurization (except for waveguide).

3.4.6.1.4 Rain.- All outdoor equipment shall be designed and constructed for storage, exposure and operation in rainfall rates of up to 100 mm of rain per hour without any sign of leakage or moisture penetration.

3.4.6.1.5 Corrosive Salt Atmosphere.- All equipment shall be designed and constructed for storage and operation during and after being exposed to a salt atmosphere with a sea spray aerosol concentration of 30 micrograms per cubic meter of air. Salt water immersion shall not be a requirement.

3.4.6.1.6 Winds.- All external equipment shall be designed and constructed for operation, storage, and exposure to winds up to 115 mph plus gust factors of 1.6 [this does include the antenna (nonoperating) with the radome removed] as measured at 33 feet above ground level.

3.4.6.1.7 Fungus.- All equipment shall be designed to be operated and maintained using fungus-inert materials as stated in FAA-G-2100.

3.4.6.1.8 Snow and Ice Loading.- All external equipment [including the antenna (nonoperating) with the radome removed] shall be designed and constructed for operation, storage, and exposure to snow depths of 40 inches with a dead load of 20 pounds per square foot average and 40 pounds per square foot peak and to ice thicknesses of at least 2 inches.

3.4.6.2 Electromagnetic Environment.- The ARSR-4 shall be designed in accordance with the criteria in 3.8.2.5.

3.4.7 Transportability.- All assemblies, subassemblies, or units shall, in their packed-for-shipment configurations, be capable of being transported via common surface or air transportation equipment in accordance with the design requirements of AFSC Design Handbooks 1-2 and 1-11. Size, weight and physical characteristics shall be such as to not exceed the limits contained in AFR 80-18, except where degradation in performance would occur as in planar array modules.

Particular attention shall be paid during the design and manufacturing phase to insure that the equipment and units are not degraded by movement via truck over unpaved roads.

Unitized transport loads shall withstand the shocks and vibrations encountered in transportation while prepared for delivery as specified in Section 5 of Chapter 5 of the AFSC Design Handbook 1-2 with no part becoming permanently warped, deformed, damaged, or loosened, and with no permanent degradation in performance or useful life as a result of being subjected to the following conditions:

(a) Shocks of the type, intensity and duration to which the equipment may be subjected during transport. These conditions include loading and unloading from a truck, aircraft, helicopter, ship or barge.

(b) Vibrations having sinusoidal resonance and cyclings as normally encountered in:

(1) Travel on trucks over rough terrain, gravel roads, unimproved roads, or packed snow.

(2) Shipment by aircraft, helicopter, ship or barge.

3.5 Functional Design Requirements.- The functional design requirements of the ARSR-4, as defined in this specification, shall be met by the contractor; however, detailed implementation architecture shall be left to the contractor's discretion. For example, the BTP or message formatting function could be partitioned into several processors if appropriate.

Due to the physical characteristics of some of the ARSR-4 sites, the ARSR-4 shall be designed in such a manner as to accommodate the equipment building outer wall and the base of the tower being separated by as much as 300 feet. The contractor shall take into consideration all losses due to this characteristic and accommodate any factors resulting for this separation.

The ARSR-4 design shall be standardized for all systems delivered. With the exception of the software site adaptation parameters, system adjustments and alignments, and site-unique installation items such as conduit, ductwork, and cable lengths, all systems shall have the same identical hardware LRUs and software modules configuration so that any system delivered to the Government could be relocated and/or installed at a different ARSR-4 site without any additions to the configuration. The ARSR-4 shall be designed and delivered in such a way that only changes to the site adaptation parameters and system alignment and adjustments for site specific environmental tailoring are needed in the configuration when the system is moved from one location to another.

Figures 3-2 and 3-3 are functional block diagrams showing both the functional relationships between the subsystems of the ARSR-4 and the functional relationships of the ARSR-4 and the EIE. Although two separate block diagrams are shown, one is for the ARSR-4/Mode S and one of the ARSR-4/ATCBI-5 cases, only one model of the ARSR-4 is permitted that will interface with either Mode S or ATCBI-5. These figures do not imply any preferred physical block diagram and are only included to aid the contractor's understanding of the functional relationships required. For example, the editor shown in the same block with the formatter could physically reside with the scan to scan correlation at the contractor's discretion.
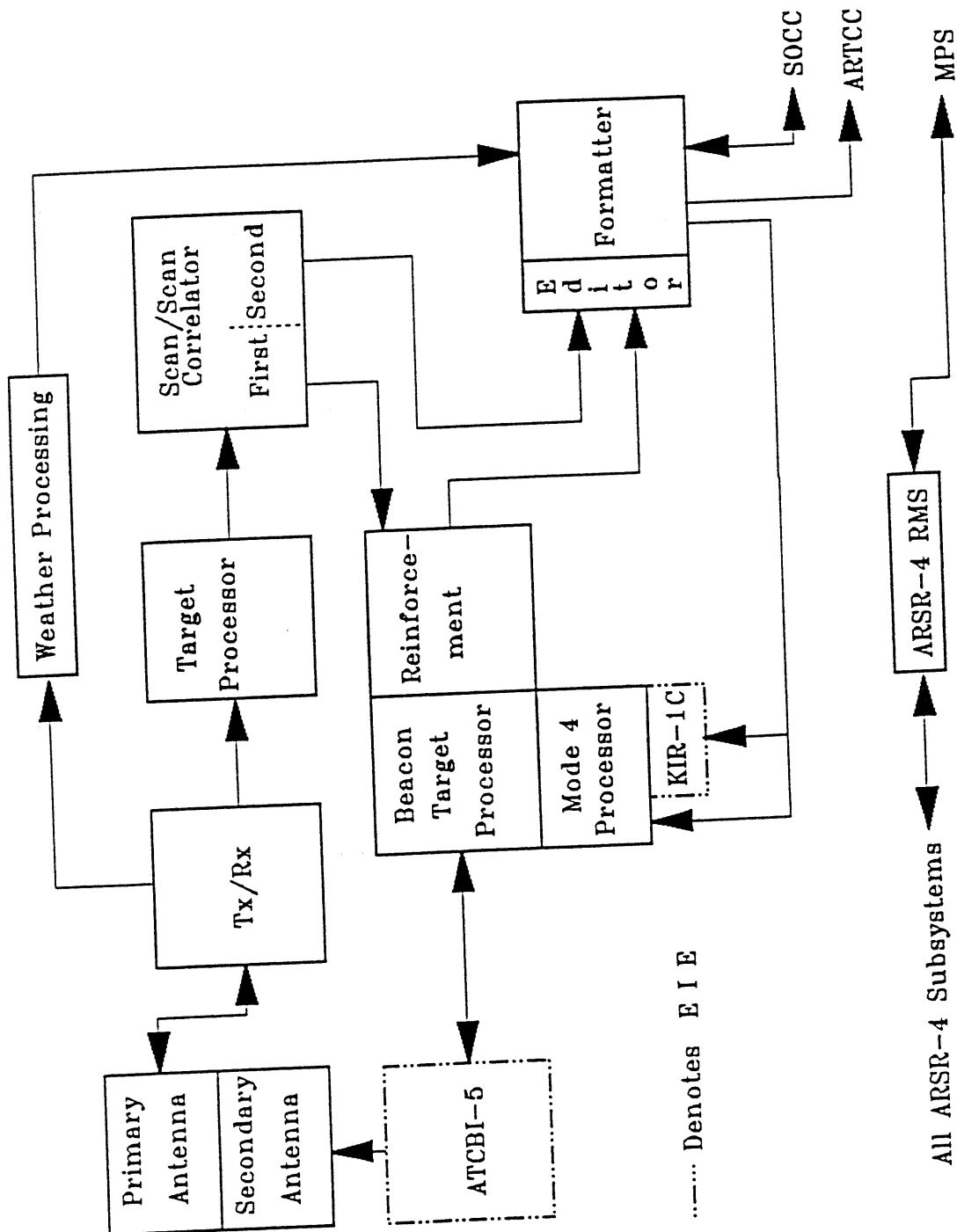
Figure 3-2, ARSR-4 WITH ATCBI-5
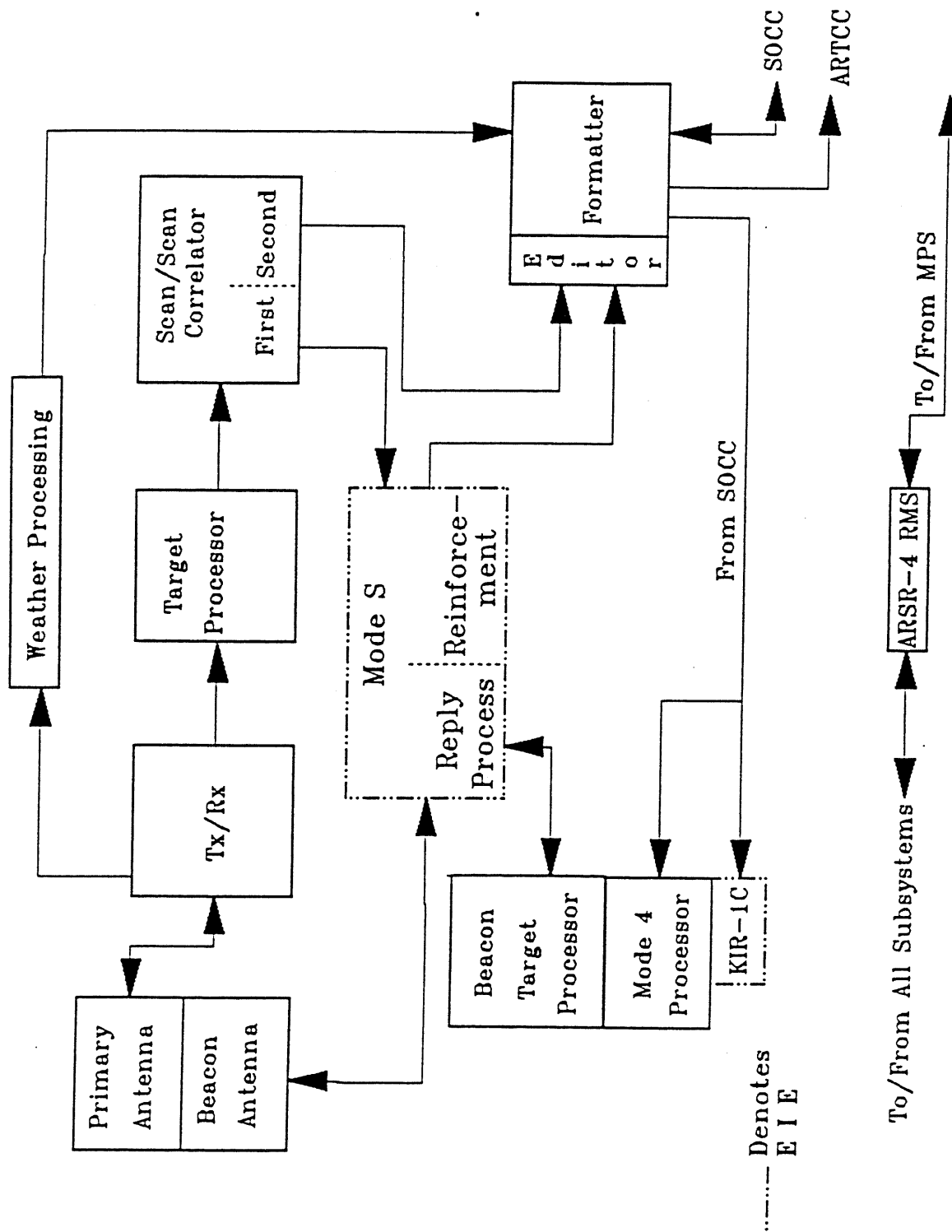
Figure 3-3, ARSR-4 WITH MODE S

3.5.1 Radome.- The radome (CFE) will be mounted upon the platform deck of the antenna tower. All requirements specified in this specification shall take into account any effects induced by the radome. The radome shall provide an environmental enclosure at L band (1,000 MHZ - 1,400 MHZ) for the ARSR-4 antenna (3.5.2) with zero, one, or two phased array beacon antennas (3.5.2.1) mounted, and it shall be capable of withstanding the environmental conditions described in 3.4.6. The radome shall have an inside diameter of sixty feet maximum at its widest point. The radome shall not degrade the operational performance of the Mode S or ATCBI-5 systems. The radome, with the primary radar installed, shall allow (without radome removal) the installation or replacement of the beacon antennas. The radome shall be entirely nonmetallic (except for fasteners) and be attached at the base to the tower platform.

The radome shall be an oblate spheroid or spherically shaped structure that provides optimal protection of the enclosed antenna assemblies from the outside environment. This radome is supplied as a complete assembly that includes a lightning protection subsystem, aircraft obstruction lights, access hatches, and all ancillary devices or units necessary for radome operation and maintenance.

3.5.1.1 Major Unit List.- Each radome shall be complete and in conformance with all specified requirements, and shall include, but not be limited to the following items:

    (a)   Radome (with airlock and equipment hatch(s) as necessary)

    (b)   Lightning protection assembly

    (c)   Aircraft obstruction light assembly

    (d)   Repair kit and maintenance items

    (e)   Ancillary equipment

    (f)   Zenith hatch assembly

    (g)   Service hatch

    (h)   Catwalk access hatch

    (i)   Interior safety ladder

    (j)   Interior block and tackle assembly

    (k)   Crown vent. If, in order to meet the temperature stratification requirements of paragraph 3.5.1.2.7, the crown vent needs to be opened and closed, then remote actuation provisions via RMMS shall be provided.

    (1)   Snow rope

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3.5.1.2 Physical Characteristics.-

3.5.1.2.1 Internal and External Surfaces.-
The radome shall provide weather effects resistance such that weathering will not preclude the radome from obtaining its 20 year service life. The radome exterior surface shall retain its hydrophobicity throughout this service life. The radome shall be in compliance with the weathering requirements of ASTM-G-53-84.

3.5.1.2.1.1 Water Penetration.-
There shall be no water, water condensate or moisture penetration or absorption into any radome wall, laminates, composites, thick wall construction, unit or subunit of the radome.

There shall be no water or moisture penetration through any radome panel or other structure joints throughout the 20 year specified service life of the radome. Wall construction shall be non-water absorbent such that if radome damage shall occur the exposed wall edges shall not absorb water more than that amount permitted in passing the quality assurance provisions of this specifications.

3.5.1.2.1.2 Hydrophobic Surface.-
The exterior surface of the radome electromagnetic window exterior surface shall be hydrophobic in the context of being non-water filming (non-sheeting) at water contact angles as measured on contact angle viewers as required by the quality assurance provisions of this specification. The radome shall incorporate an integral 20 year service life hydrophobic (non-sheeting) surface not subject to peeling, delamination of wall construction, or rapid erosion. The surface shall not crack, craze or delaminate over a 20 year exposure with extreme temperature ranges specified in 3.4.6 and under severe environmental conditions including ultraviolet light, ozones, salts, acids, and alkalines. These requirements shall apply both prior to and subsequent to conduct of the advanced weathering tests.

3.5.1.2.1.3 Protective Coating.-
The radome exterior surface shall be impervious to ultraviolet light or other environmentally caused deterioration throughout its 20 year service life without any requirement to resurface, recoat or paint the surface. The protective coating material shall be permanently bonded to any sub-surface material in a nondelaminating fashion with a 20 year or longer bonding permanence.

3.5.1.2.1.4 Solar Radiation.-
Regardless of its color, the radome shall possess solar reflective qualities such that the solar admittance factor F_A shall not exceed 0.12 using the formula $F_A = T_s + 0.2 A$. (T_s is solar transmittance and "A" is absorptance).

3.5.1.2.1.5 Ice or Snow Adhesion.-
The radome exposed surfaces shall exhibit a measurable ice adhesion of less than 10 Pounds per square inch shear at a temperature of -5 degrees C. The radome shall be constructed in a manner that minimizes the formation of rime ice by using construction techniques that provide minimal surface discontinuities.

3.5.1.2.1.6 External Color.- The exterior color of the radome shall normally be a shade of white. A few sites may require other colors (e.g., a light color such as spruce green, light blue, beige, etc.) due to its aesthetic impact to the environment. The overall ARSR-4 design shall accommodate for the impact due to these other colors being used at these few sites. The ARSR-4 shall operate in the environmental conditions at all sites regardless of the radome color as specified in 3.4.6. The shade of white used shall be subject to Government approval. The selection of other colors to be used at those aforementioned few sites shall be determined by the Government upon request by the contractor. Deviations, subject to Government approval, from the specified total site power (3.6) shall be commensurate with the additional cooling required due to the change in color from the nominal shade of white.

3.5.1.2.2 Flammability and Combustibility.- The radome material shall be nonflammable and noncombustible when tested to the requirements of Federal Aviation Regulations, Part 25.853(b), using the test methods of Part 25, Appendix F, Part 1.

3.5.1.2.3 Temperature Stability.- Radome material shall retain its stability throughout a temperature range of -75 through +95 degrees C.

3.5.1.2.4 Physical Stability.- Materials used in radome construction shall demonstrate a physical stability such that movement under the environmental extremes specified in 3.4.6 shall not cause the radome to contact the antenna structure.

3.5.1.2.5 Snow Rope.- A stranded rope of 5/8 inch or greater diameter that is ultraviolet light and weather resistant shall be provided for use as a snow removal rope. This rope shall be attached to a pivot assembly at the top of the radome. It shall be made from a material that will not produce any ill effects to the ARSR-4 and beacon (Mode S or ATCBI-5) radiation patterns.

3.5.1.2.6 Aerodynamic Loading.- The radome shall be designed in such a manner that ensures it is aerodynamically sound in terms of lift, drag, moment, and compound stresses. The radome shall be capable of withstanding winds from any direction and at velocities as specified in 3.4.6.

3.5.1.2.7 Thermal Temperature Gradients.- Temperature stratification within the radome enclosed volume shall be constrained by the following temperature gradients:

   (a)   The temperature difference from the antenna deck (floor) to the center of the primary antenna shall not exceed 6 degrees C.

   (b)   The temperature difference from the antenna deck to the center of the uppermost mounted antenna shall not exceed 8 degrees C.

Temperature stratification control is permitted by the use of radome exterior solar reflective qualities, by radome crown venting, or both.

3.5.1.2.8 Nameplates or Product Markings.- The radome shell shall not have any metallic nameplate attached to its surface interior or exterior and shall contain no exterior marking. Radome shells shall be marked with the required FAA-G-2100 data on an inside surface 12 inches above the mounting ring by using non-RF reflective marking.

3.5.1.2.9 Radome Air Lock.- Air supported radomes shall contain a personnel entryway/pressure lock assembly/room containing separate personnel entrance and exit doors with pressure equalization.

3.5.1.2.10 Lightning Protection.- A lightning rod attached to the radome zenith hatch assembly crown plate shall provide a minimum 60 degrees cone of protection relative to the antenna assemblies and shall be capable of dissipating direct lightning strikes without radome and radar damage.

3.5.1.2.11 Aircraft Obstruction Lights.- A redundant aircraft obstruction light assembly shall be provided and meet the performance criteria of AC 70/7460-1. Remote maintenance monitoring of the obstruction lights will be performed via the ARSR-4 RMS. The assembly monitoring leads shall be routed in such a manner so that the radiation requirements herein are met.

3.5.1.3 Auxiliary Equipment.- Thin-skin, single-skin or air-supported radome auxiliary equipment shall operate in a fail-safe mode such that automatic control equipment provided by the contractor shall activate pressurization equipment required to sustain pressurization necessary to maintain radome integrity for the highest wind speed. The contractor shall provide independent emergency equipment that ensures radome inflation for a 6 hour period, designed for use in the event that the Government facilities emergency back-up electrical power generation system fails to operate. This contractor supplied emergency equipment may use compressed air tanks, batteries, or any other emergency backup system that can be demonstrated as being adequate for the requirements. In the event of failure of wind speed detecting and indicating devices, of which 2 each shall be provided for air-supported radomes, the fail-safe mode shall activate pressurization subsystems within a maximum time of one minute to provide internal air pressures necessary to maintain radome integrity for the highest wind speed for which the radome is designed. Wind speeds up to 188 mph (+/-2 mph) shall be detected and shall be indicated in 2 mph increments. Wind speed indications shall be made available to the Maintenance Processor Subsystem (MPS) via the ARSR-4 RMS.

3.5.1.3.1 Remote Maintenance Monitoring.- Each unit of radome auxiliary equipment shall be monitored via the ARSR-4 RMS. Normal operation and failed operation outputs shall be provided to the ARSR-4 RMS for each unit necessary to maintain radome integrity.

3.5.1.4 Electrical Performance Requirements.- All ARSR-4 performance requirements stated herein shall be met with the ARSR-4 antenna installed in the radome. The electrical performance requirements in the following subparagraphs apply to the beacon antenna(s) radiation patterns as they are affected by the radome. Distortion of the beacon spatially distributed electromagnetic radiation patterns shall not exceed these requirements.

3.5.1.4.1 Antenna Main-Lobe Beamwidth Error.- Over the Mode S antennas' operating frequency, the radome shall not cause the Mode S antennas' main lobe beamwidth to narrow or broaden by more than 0.05 degrees at the main beam's (sum) half power points.

3.5.1.4.2 Boresight Error.- The radome shall not cause the direction of any antenna pattern main beam axis to change by more than 0.00085 degrees rms and 0.025 degrees maximum. This requirement applies to both the elevation and azimuth planes (pointing angles throughout 360 degrees in azimuth and between -10 and +50 degrees in elevation) at any antenna operating frequency with the antenna rotating at speeds of 0 RPM through 20 RPM.

3.5.1.4.3 Boresight Error Slope.- The radome shall not cause the rate of change (slope) of boresight error during any 360 degrees of antenna rotation (scan) at any antenna rotation rate of from zero RPM through 20 RPM to exceed a maximum of +/-0.05 percent. This requirement also applies throughout elevation of -10 through +50 degrees with the antenna rotating at speeds of 0 RPM through 20 RPM.

3.5.1.4.4 Difference Pattern Null Depth Error.- The radome shall not cause changes in the depth of the Mode S antennas' difference pattern nulls to exceed a +0.57 dB rms and +1.7 dB maximum at a null depth of -30 dB. This requirement applies to both the elevation and azimuth planes (pointing angles throughout 360 degrees in azimuth and between -10 and +50 degrees in elevation) at any antenna operating frequency with the antennas rotating at speeds of 0 RPM through 20 RPM.

3.5.1.4.5 Sidelobe Level Error.- The radome shall not cause changes exceeding +/-1.0 dB in the Mode S antenna pattern sidelobes at a level 25 dB down from the peak of beam for all frontal and back sidelobes.

3.5.1.4.6 Cross Polarization Ratio.- The radome shall not cause the cross polarization ratio of the Mode S antenna to change by more than +/-1.0 dB at a level 25 dB down from the peak of beam for all frontal and back sidelobes.

3.5.1.4.7 Transmission Loss.- Total radome two way transmission losses of reflection loss plus attenuation loss and any other losses caused by the radome shall not exceed 0.2 dB when the radome is in a dry condition, provided that all error requirements are met.

3.5.2 Radar Antenna.- The ARSR-4 antenna shall be housed within the radome (CFE). The antenna beam shall rotate at 12 seconds per scan (five rpm) plus or minus 0.10 seconds. At all operating frequencies and all beam pointing angles, all sidelobes in the principal azimuth plane shall not exceed -30 dB from the peak of beam. From two to eight 3-dB beamwidths on either side of the main beam, sidelobes shall not exceed -35 dB from the peak of beam. All sidelobe requirements shall be met on three trial frequencies when measured on the antenna test range specified in appendix E. One sidelobe pop-up above the specified requirements is allowed for one of the three trial frequencies. The aforementioned specification applies to the one way receive pattern. Transmit sidelobes shall not be degraded by more than +5 dB from the specified receive sidelobes at the same offset angle.

At all operating frequencies and all beam pointing angles, all sidelobes in the principal elevation plane shall not exceed -25 dB from the peak of beam for the one-way receive pattern.

At all operating frequencies and at all beam pointing angles, the sidelobes in the intercardinal plane shall not be degraded from that specified in the principal azimuth plane. The gain pattern shall also meet the criteria for allowable radar antenna patterns stated in Radar Spectrum Engineering Criteria section of the Manual of Regulations and Procedures for Federal Radio Frequency Management. The cross polarized components of the antenna for both the azimuth and elevation principal planes shall be at or below the level specified for sidelobes, except that within the area of the main lobe, the cross polarized components shall be at least 18 dB below the peak of the associated beam.

The normal operating mode for the antenna shall be linear polarization. If it is necessary to use circular polarization to achieve the required performance in precipitation clutter, the switching between linear and circular polarizations shall be done automatically by sensing when and in what areas the detection performance is being degraded due to precipitation. Circular polarization shall be automatically gated by sectors so as to encompass these area(s) while at the same time minimizing the use of circular polarization in area(s) where precipitation clutter does not exist. A field adjustable provision shall be incorporated so that precipitation clutter returns up to any selected range between 5 and 92 nm will not result in the switching to circular polarization. In addition, a field selectable capability shall be provided to override the automatic circular polarization selection, so that the ARSR-4 can be made to remain in linear polarization regardless of the environmental conditions. The integrated cancellation ratio for circular polarization, if used, shall be adequate to support the 15 dB rain rejection specified in Appendix A. If circular polarization is included, a signal path shall be provided to permit the reception of weather returns using the opposite sense polarization from the transmitted signal when circular polarization is selected.

The antenna shall possess a mechanical or electrical elevation tilt, site selectable from plus to minus 3 degrees in elevation with respect to the normal antenna face angle as installed. The tilt selection shall be achieved in discrete increments not to exceed 0.10 degree per step. If a mechanical adjustment is used, shimming is acceptable; however, a complete set of shims shall be provided with each system. Compensation for tilt changes shall be provided for the height determining algorithm on a site adjustable basis.

If monopulse techniques are used, the sidelobes of the Sum pattern shall meet all of the previously specified sidelobe requirements. The sidelobes of the Difference pattern shall meet all of the previously specified sidelobe requirements. However, the peak of beam reference for the Difference pattern sidelobes measurement shall be the peak of the Sum beam. The beamwidth reference for the Difference pattern shall be the beamwidth of the Difference beam (the combined width of the two main lobes of the difference pattern).

3.5.2.1 Beacon Antenna Provisions.- All ARSR-4 systems shall be designed to accommodate any of three beacon antenna (FAA-E-2751 for the antenna(s) only and not those sections that specify any ancillary units such as rotary joints, filters, cables, etc. Those other ancillary units shall be provided as part of the ARSR-4 and shall be subject to the requirements stated herein.) configurations without modification of hardware or software. The three beacon antenna configurations are:

(a) Single beacon antenna, primarily for use at sites with ATCBI-5 equipment. The radiation pattern of this single beacon antenna shall be aligned with the peak of beam of the primary antenna radiation pattern.

(b) Dual (two beacon antennas mounted back-to-back) beacon antennas, for use at sites with ATCBI-5 or Mode S equipment. When Mode S is used in conjunction with this configuration, the radiation pattern of the front antenna shall be aligned with the peak of beam of the primary antenna radiation pattern. The back antenna radiation pattern shall be 180 degrees away from the front antenna radiation pattern. If the dual configuration is used with the ATCBI-5 equipment, only the front antenna shall be used [excluding the Integrated Side Lobe Suppression (ISLS) pattern] and shall have its radiation pattern aligned with the peak of beam of the primary antenna radiation pattern.

(c) No beacon antennas.

All primary radar performance requirements (both mechanical and electrical) shall be met, regardless of which beacon antenna configuration is used. All beacon antennas will be GFE, and all beacon (Mode S and ATCBI-5) and ARSR-4 requirements stated herein shall be met while operating with any of the three beacon antenna configurations.

The mounting provisions shall be supplied by the ARSR-4 contractor and shall permit leveling and alignment of the beacon antennas about the three coordinate axes over the full range of the primary radar antenna mechanical tilt adjustments. Additionally, independent vertical tilting adjustment of ± 3 degrees, horizontal tilting adjustment of ± 5 degrees, and canting adjustment of ± 5 degrees shall be provided. All electrical/mechanical connections between all three ports of each beacon antenna and the six ports of the rotary joint (3.5.3.1) (e.g. cabling, filters, mounting pads) shall be provided and installed by the ARSR-4 contractor regardless of which beacon antenna configuration is used. The ARSR-4 contractor shall provide and install the RF transmission line from the ATCBI-5 to the three rotary joint ports feeding the single beacon antenna or the front beacon antenna at those ATCBI-5 sites where (as determined by the Government) two beacon antennas are to be mounted. RG-333 (2.1 dB attenuation per 100 feet at 1,000 MHz) or equivalent shall be used. The beacon antennas shall be mounted inside the CFE radome on the ARSR-4 antenna so that degradation of both the beacon and primary antenna patterns do not occur and all other specification requirements herein and in FAA Order 1010.51A, FAA-E-2716, FAA-E-2751, and FAA-E-2319 are all achieved. The ARSR-4 primary antenna pattern shall meet the requirements stated herein with or without the beacon antennas mounted. Mounting of the beacon antennas shall be in such a manner as to allow ease of maintenance on both the primary and beacon antennas.

3.5.2.2 **Antenna Alignment**.- The structural rigidity of the beacon antennas' mounting provisions shall be designed in such a manner that while operating at 5 RPM, the maximum power points of the azimuth radiated beam of the beacon antennas shall be no more than 0.1 degree from the correct position of the maximum power point of the radiated beam of the ARSR-4.

3.5.2.3 **Mutual Interference**.- The contractor shall ensure that Mode S or ATCBI-5 and the ARSR-4 operate without electromagnetic interference from each other. If antenna location does not provide the necessary isolation between the two systems, the contractor shall provide electromagnetic filtering, electromagnetic shielding and signal processing to eliminate inband and spurious emission interference. The filtering shall provide spurious frequency attenuation and out of band rejection to the Mode S or ATCBI-5 and ARSR-4 transmitters and receivers such that interference noise levels do not exceed -114 dBm/MHz for 3dB IF bandwidths in the ARSR-4 receiver and -105 dBm/MHz for 3dB IF bandwidths in the Mode S receiver. Mode S filtering shall be installed in the Mode S transmitter transmission line and Mode S receiver transmission lines supplied under the ARSR-4 contract. Insertion loss of the Mode S receiver filters shall be no greater than 1 dB. Phase and amplitude errors in the Mode S sum and difference transmission line filters must track over time with peak to peak phase and amplitude errors no greater than 10 degrees and 0.2 dB respectively.

In addition to filtering, the contractor shall provide shielding of the rotary joint and other units to prevent interference between the two systems from other means than antenna to antenna coupling. The shielding and filtering supplied shall not degrade the Mode S, ATCBI-5 and ARSR-4 systems below their specified performance levels.

3.5.3 Pedestal.- The pedestal shall be designed to support the antenna described in 3.5.2 and 3.5.2.1, drive mechanisms, azimuth pulse generators, rotary joints, and other units required for system operation. At a minimum, the pedestal shall contain dual 12-bit and 14-bit Azimuth Pulse Generators [APGs (4,096 and 16,384 pulses per scan)] (3.5.3.2) and dual AC drive motors. The APGs and the AC drive motors shall be replaceable without an antenna shutdown (including radiation). The pedestal shall also have provisions for leveling and contain an adjustable azimuth reference ring.

3.5.3.1 Rotary Joint.- The rotary joint shall accommodate six sections for Mode S (Sections 1 through 6). The required characteristics for these sections are listed below.

(a)	Frequency Range	1026-1034 1085-1095 MHz
(b)	Peak Power (Unpressurized)	10 KW
(c)	Peak Power (Pressurized)	10 KW
(d)	Duty Cycle (percent)	1.0*
(e)	Maximum VSWR	1.2:1
(f)	Maximum VSWR change	0.05 for 360 degree rotation
(g)	Phase Shift (Maximum excursion in 360 degree rotation and maximum rate of change in 30 degree rotation).	± 5 degrees**
(h)	Maximum insertion Loss	1.0 dB**
(i)	Minimum isolation between	60 dB any two sections

* Shall handle maximum duty cycle of Mode S transmissions as defined in FAA-E-2716.

** Throughout the frequency range from 1025.0 to 1035.0 MHz, the insertion loss of sections 1 and 2 and sections 5 and 6 shall be the same to within 0.1 dB and the phase match through each of these pairs of sections shall be the same to within 5.0 degrees. Throughout the frequency range from 1085 to 1095 MHz, the insertion loss of sections 1 through 3 and sections 4 through 6 shall be the same to within 0.1 dB and the phase match through each of these sections shall be the same to within 5.0 degrees. Sections 1 through 3 and sections 4 through 6 shall meet the following additional requirements when a standard Mode S reply pulse having rise and fall times less than 50 nsec is transmitted through these sections. The rise and fall times of the output pulses shall be less than 60 nsec, and the output pulses shall be flat to within -15 percent of their respective peak amplitudes over the pulse duration of 0.5 μsec (that is, between the 90 percent amplitude points on the leading and trailing edges). Between the 10 percent and 90 percent amplitude points on the leading and trailing edges of the output pulses, the pulse shapes in sections 1 through 3 and sections 4 through 6 shall be the same to within ± 10 percent of the input pulse amplitude of the respective sections. Between the 90 percent amplitude points on the leading and trailing edges of the output pulses, the two pulse shapes shall be the same in ± 5 percent of the input pulse amplitude of the respective sections.

3.5.3.1.1 Phase Shift Tolerances.- The transmission paths between the sum and difference ports of each of the array antennas and the rotary joint shall be phase equalized so the differential phase shift between the two sections at 1,090 (± 5) MHz, shall be less than 3 degrees. The total differential phase shift between paths through the adapter cables, the rotary joint, and the cables from the rotary joint to the antenna assembly shall not exceed 5.0 degrees. Losses due to unit and transmission lines shall not exceed 1.75 dB for each of the six signal paths from the antenna assembly to the rotary joint. Over the frequency band 1,090 (± 5) MHz this insertion loss shall not vary by more than ± 0.2 dB.

3.5.3.2 Azimuth Pulse Generator (APG).- Two APGs shall be provided and each APG shall generate two pulse groups. These two groups shall consist of 12 and 14-bit Azimuth Change Pulses (ACPs) and their associated Azimuth Reference Pulses (ARPs). The 12-bit data shall consist of 4096 data pulses, plus one reference pulse, and the 14-bit data shall consist of 16,384 data pulses, plus one reference pulse, for each 360 degrees of rotation. The 12-bit data pulses shall be referred to as "ACPs" and the 14 bit data pulses shall be referred to as "IACPs" (I = Improved) from here on. The APGs shall be designed to provide total compliance to the position accuracy requirements below. The APGs shall be adjustable ± 15 degrees, minimum; enabling the alignment of the ARP.

The pulse-to-pulse jitter of the ACPs shall be no greater than ± 10 percent of the nominal spacing. The ARP jitter shall be no greater than ± 20 percent of the ACP spacing. The output characteristics of ACPs and the ARP as derived from each of the APGs shall be as follows:

(a) 14-bit IACP Lines
          Frequency   16,384 pulses per revolution
          Voltage   Line driver output (SNC 55183 or
                                  equivalent)
          Pulsewidth   2 to 6 μsec
          Pulse shape   Rectangular, 50 percent duty cycle
          Pulse position   ± 40 arc sec absolute
                                ± 20 arc sec bit to bit

(b) 14-bit ARP Line
          Frequency   1 pulse per revolution
          Voltage   Same as ACP
          Pulsewidth   Same as ACP
          Pulse shape   Rectangular, 50 percent duty cycle
          Pulse position   ± 20 arc sec absolute
            (leading edge)   Coincident with the IACP leading edge
                                Coincident with the 12-bit ARP leading edge
                                (The ARP shall not lead the IACP by more
                                than 0.015 μsec.)

(c) 12-bit ACP Line
          Frequency   4096 pulses per revolution
          Voltage   Line driver output (SNC55183 or equivalent)
          Pulse shape   Rectangular, 50 percent duty cycle
          Pulse position   ± 1.0 arc minute absolute
                                ± 20 arc sec pulse to pulse

(d) 12-bit ARP Line
          Frequency   1 pulse per revolution
          Voltage   Line driver output (SNC55183 or equivalent)
          Pulse shape   Rectangular, 50 percent duty cycle
          Pulse position   Midway between two clockwise ACPs ± 30
                                percent

(e) Output Isolation: Isolation between ACP and ARP signals,
                                including hum and noise, shall be ≥40 dB.

The above characteristics shall be met when measured at the end of a terminated cable for any cable length up to 300 feet.

3.5.4 Transmitter.- The transmitter shall be complete with Radio Frequency (RF) circuitry and any other ancillary units needed to meet the requirements of this specification. The normal operating peak power shall be that level required to provide the coverage required in 3.4. The transmitter shall be all solid state and of modular design. It shall have provisions for two sectors of transmitter azimuth blanking, separately adjustable in angular position (0 to 360 degrees) and width (0 to 180 degrees). Spectrum measurement(s) shall be capable of being done on the operating system by an average technician at the field site using BITE or external test equipment.

3.5.4.1 Operating Frequency.- The transmitter shall be capable of operating at any frequency(ies) between 1215 MHz and 1400 MHz, as determined by the Radio Frequency Generator (RFG), without manual adjustment. The operating frequency(ies) shall be determined by crystal controlled sources and shall have the capability specified in 3.4.1.15.1. The Government will assign the operating frequency(ies) for each system and will advise the contractor of the operating frequency(ies) at least 120 days prior to the scheduled delivery of the system.

3.5.4.2 Transmitter Cooling.- The transmitter shall be cooled by means of natural convection or forced air. If forced air flow is used, air flow and over temperature interlocks shall be provided to protect the transmitter. Transmitter cooling air flow shall be in accordance with 3.8.1.5.

3.5.4.3 Voltage Standing Wave Ratio (VSWR).- The transmitter shall operate without damage into a 2.5:1 mismatch for a minimum of five hours.

3.5.4.4 Protective Circuitry.- Protective circuitry shall be provided as necessary to prevent damage to transmitter parts.

3.5.5 Receiver.-

3.5.5.1 Sensitivity Time Control (STC).- STC shall provide time-varying gain characteristics, site adjustable in azimuth in 11.25 degrees sectors for each elevation receiver path. Range at which full gain is reached shall be site adjustable in one nm increments from 5 to 160 nm and shall have a slope site adjustable in one dB increments between R^{-2} to R^{-4} (R = range).

3.5.5.2 Receiver Video Output.- Monitor points within and on each receiver path shall be provided by the manufacturer. A linear video output $(I^2 + Q^2)^{1/2}$ for each receiver, suitable for display on the LDC and an A-scope, shall be provided. This output shall be a synchronous (destaggered) wideband analog video output. In addition, this output shall provide composite IFF information, a 100 μsecond pretrigger for each radar update, 12 bit azimuth change and azimuth reference information, Moving Target Indicator information (Doppler), and normal video (including clutter).

3.5.5.3 Receiver ElectroMagnetic Compatibility (EMC).- The receiver shall meet the criteria for radar receivers stated in Radar Spectrum Engineering Criteria section in the Office of the Manual of Regulations and Procedures of Federal Radio Frequency Management" issued by the National Telecommunications and Information Administration (NTIA). If a wide band preamplifier is used, then it shall have a -20 dBm, 1dB gain, compression point.

3.5.5.4 Protective Circuitry.- Protective circuitry shall be provided as necessary to prevent damage to receiver parts. Protection of the receiver parts (e.g., low noise amplifiers, preamplifiers) from external radiation sources shall be provided.

During ARSR-4 installation, the new radar may be installed next to an existing operational radar. The ARSR-4 shall be designed so that an ARSR-1, ARSR-2, ARSR-3, AN/FPS-20 series, or AN/FPS-6/90/116 radar antenna center point located 50 feet, or more, from the center point of the ARSR-4 antenna does not cause damage to the ARSR-4. The existing adjacent radar will have its main beam blanked at the azimuthal direction of the ARSR-4. Sidelobe power levels radiated from these nearby operational radars shall be taken into account in the ARSR-4 design, protecting any sensitive parts. No hardening against electromagnetic pulse or nuclear radiation is required.

3.5.6 Clutter Processing.- The ARSR-4 system shall be capable of meeting all of the specified target detection and false report requirements in the specified clutter environments and in the actual site clutter environment. All clutter processing techniques employed shall be capable of full adaptability to the actual clutter conditions at each site. This adaptability shall be capable of contending with all types of clutter in any combination on an azimuth, range, and elevation basis, as may be experienced in the actual operational environment. Clutter processing shall be available over the entire coverage volume (3.4.1.1) on each 360 degree scan. If clutter levels in range, azimuth, and elevation cells at a radar site are more stringent than that specified, the contractor may only degrade target detection performance in those cells for terrain, rain, and angel clutter that exceed the values specified. However, this degradation of target detection performance shall only be permitted in the range, azimuth, and elevation cells where the contractor can prove to the Government that these terrain, rain, and angel clutter levels experienced exceed the specified levels. At no time under any clutter environment shall the ARSR-4 system exceed the 194 false reports requirement specified in paragraph 3.4.1.6. The contractor will be allowed after contract award to visit the operational sites to substantiate the clutter levels at ARSR-4 sites as described in the SOW. The ARSR-4 shall have analog normal videos available at the LDC from various stages in the processing chain as specified in 3.5.16.2, providing the capablility to view the clutter environment at the LDC.

Appendix A describes the radar clutter model for terrain clutter, sea clutter, rain clutter, ground vehicles, angels and AP. The ARSR-4 design shall address each of these clutter environments (3.4.1.2 and 3.4.1.7). If different waveforms are required to meet the specified Pd for different environments, the system shall automatically sense that clutter environment and select from a waveform menu waveform(s) that will maintain the required detection and false alarm rate requirements. The ARSR-4 shall provide for the elimination of nonsynchronous interference (i.e., pulse energy radiating at PRF(s) differing from the ARSR-4) during operation in all different clutter environments and all waveforms used. Ambiguous waveforms (ambiguous waveforms are waveforms used to meet coverage requirements beyond their first listening period) shall not be used, and the waveform(s) used shall be selected so as to minimize multiple trip returns from lowland clutter during normal propagation conditions. To the extent commensurate with the false report requirements, provisions shall be made to minimize the detection loss when surface clutter exceeds levels equal to σ_o of -14 dB. Provisions shall be made for monitoring up to five permanent echoes, allowing the verification of range and azimuth of the search data. These permanent echo monitoring sectors shall be adjustable up to 2 degrees by 2 nm in size and shall employ no clutter processing in those sectors.

3.5.6.1 Terrain Clutter.- The ARSR-4 shall provide the capability to detect aircraft targets in the presence of ground clutter. The clutter model describes three types of ground clutter, namely, that from mountains, wooded hills and lowlands. The spatial amplitude distribution and the velocity density function are different for all three types. In order to keep to a minimum the tangential blind speed sector for aircraft, the ground clutter suppression techniques shall address each type of ground clutter so that the zero velocity rejection notch is no wider than that needed to provide the ground clutter suppression necessary to meet the aircraft detection requirements specified in 3.4.1.2 and the false alarm requirements specified in 3.4.1.6. In addition, a superclutter and interclutter capability shall be provided to cover all radial velocities from 0 to Max V knots (Max V is the maximum radial velocity as referenced in Table 3-1 footnotes). This capability shall continuously adjust to temporal changes in the clutter environment.

3.5.6.2 Weather Clutter.- The ARSR-4 clutter processing shall provide a superclutter capability for aircraft whose radial velocity falls within the region of the radial velocity of the precipitation. The detection capability shall be that necessary to meet the requirements specified in 3.4.1.2, based on the overall system weather rejection capability.

Based on the specified target capacities (3.4.1.8) and the specified false reports (3.4.1.6), the contractor shall establish those areas within the specified coverage where the average data count is higher then should be expected. Restricted to those areas, at altitudes and/or elevations appropriate for angels, the contractor may degrade detection capability. The degradation shall not be greater than that which will provide 80 percent Pd for a 2.2m² target for the specified velocity visibilities. The reduction in detection capability shall be done in such a way as to minimize the degradation of those targets having radial velocities greater than 60 knots. In addition, a field adjustable override feature shall be provided to raise or lower the 2.2m² target reference level between the minimum detection level specified in Table 3-1 and 10m² in 1 dB increments. However, this override feature shall not be used to meet the specified false report rate. A field selectable capability shall be provided to turn this detection degradation function on or off. The method selected by the contractor to accomplish the above shall not degrade range and azimuth accuracy.

3.5.7 Search Target Extraction.- Search target extraction shall produce a single target report for each detectable aircraft target within the coverage volume on each scan of the antenna to the range, azimuth and height accuracies specified in 3.4.1.9. The range and elevation data along with the atmospheric refraction correction factor (3.5.24) shall be used to compute the altitude. Site adjustable altitude compensation for antenna tilt changes shall be provided. Vehicular traffic targets may be inhibited by fixed mapping techniques within the lowest beams to the extent applicable. The extracted target reports shall be used for search/beacon reinforcement or shall be remoted via the first function of the scan to scan correlation function to the Mode S processor. The interface requirements for Mode S are given in section 3.5.18.

In the event that a technique other than circular polarization is used to meet the requirement for detection in rain, such technique shall not degrade detection in the other environments by more than 3dB below that specified in Table 3-1. In the event that the technique does degrade performance below that specified in Table 3-1, the technique shall be selected for use by sensing when and in what areas the detection performance is being degraded due to precipitation. The technique shall be automatically gated in by sectors so as to encompass these areas, while at the same time minimizing its use in areas where precipitation clutter does not exist. The switching action from the normal detection mode of operation to the target detection in rain mode of operation shall not cause any degradation in target Pd and false alarm rates. A field adjustable provision shall be incorporated so that precipitation clutter returns up to any selected range between 5 and 92 nm, in one nm increments, will not result in the selection of this technique for use. Additionally, a field selectable capability shall be provided to override the automatic selection of this technique.

3.5.6.3 Sea Clutter.- The ARSR-4 clutter processing shall provide that sea clutter suppression necessary to meet the aircraft detection criteria specified in 3.4.1.2. A superclutter capability shall be provided in the zero velocity notch.

3.5.6.4 Anomalous Propagation (AP).- The ARSR-4 clutter processing shall provide the capability to detect aircraft during conditions of AP. AP causes the radar to detect clutter at ranges that may exceed 4/3 earth horizon but may also extend beyond the maximum instrumented range of the radar. The ARSR-4 system shall be designed to provide waveform(s) and clutter processing that will be effective on the AP returns. For system design purposes, the maximum range of the anomalous returns shall be 500 nm. The detection capabilities under ducting shall be that necessary to meet the requirements of Table 3-1 in 3.4.1.2 for clutter out to 250 nm. For ducting conditions that result in clutter returns beyond 250 nm, the ARSR-4 shall automatically sense the clutter environment and select from a menu of waveform(s) the one that will maintain the required detection and false report rate requirements, except that the velocity visibility and dim speed notch requirements may be degraded to the extent necessary to implement this feature.

3.5.6.5 Angel Clutter.- In the event that the specified angel false alarm reports (3.4.1.6) can not be met at the output of the first function of the scan to scan correlation by any other means that will not degrade system performance below that specified herein, the contractor may degrade the detection compatibility in the following manner.

3.5.9.1.2 Pulsewidth Discrimination.- A fixed width threshold shall be provided to establish the minimum acceptable reply pulsewidth criterion. Any video pulse which exceeds this threshold shall be considered acceptable. The fixed threshold shall be set so as to accept all pulses 300 nsec or wider while rejecting all pulses 150 nsec or narrower. Acceptance or rejection of pulsewidths that fall between 150 to 300 nsec shall be left to the discretion of the contractor. The width of the pulse passed to the bracket detector shall be within 100 nsec of the video pulse's width, as measured at its 50 percent amplitude point, provided that it exceeds this established minimum pulsewidth criterion. The width threshold circuitry shall be implemented using digital logic which is synchronized with, and operates at multiples of, the basic BTP detection range clock. All pulses passing the minimum pulsewidth threshold criterion shall be provided to a fixed maximum pulsewidth criterion. Any video pulse which is less than or equal to the nearest integer number of range clocks between 1.4 μsec and 1.5 μsec in width shall be considered acceptable and passed to the next processing circuit. Video pulses exceeding this maximum threshold shall be truncated to the 1.4 μsec to 1.5 μsec clock-related pulse width before being sent to the next processing circuit.

3.5.9.1.3 Bracket Detection.- The BTP shall recognize the presence of the beacon framing pulses (F1 and F2) in the video reply train by sensing the nominal 20.3 μsec spacing between their leading edges (FAA Order 1010.51A, attachment 1). If the pulsewidth of F1 is less than or equal to 0.55 μsec or if it is within 0.13 μsec of the width of F2, the leading edge of F1 shall be used as the reference for this measurement. Otherwise, the leading edge of F2 shall be used. Other algorithms for detecting brackets and determining the reply's range and, hence, the correct timing for code data sampling may be used if it can be demonstrated that it meets or exceeds the performance of the aforementioned technique. The F1/F2 spacing shall be sensed with a tolerance which is adjustable by simple internal means. This adjustment shall be implemented by sensing pulse spacings which occur within an integral number of BTP range clock pulses of the nominal 20.3 μsec spacing, provided that the range clock's frequency permits the specified tolerances to be met. The minimum tolerances within which the BTP shall declare brackets and outside of which the BTP shall not declare brackets shall be as follows for a BTP range clock period of 85 to 125 nsec.

Tolerance Setting	Acceptance	Rejection
+/-0.1 μsec	+/-1 clock period	+/-2 clock periods
+/-0.2 μsec	+/-2 clock periods	+/-3 clock periods
+/-0.3 μsec	+/-3 clock periods	+/-4 clock periods

3.5.8 Strobe Processing.-

The ARSR-4 shall produce (with 90 percent probability) a single strobe report on a single constant power noise jammer having an Effective Radiated Power between the minimum and maximum values specified in Appendix B and located at a range of 100 nm. The ARSR-4 shall produce (with 90 percent probability) main-lobe strobe signals on up to 20 equal-power jammers having Effective Radiated Power equal to the average of the values specified in Appendix B and located at ranges distributed uniformly between 50 and 300 nm; under worst-case conditions, all jammers shall be distributed uniformly over a 90 degrees azimuth sector. Strobe (azimuth-only) accuracy shall be 0.27 degree (one standard deviation). The ARSR-4 shall be capable of resolving (50 percent probability) two equal-power jammers emitting maximum power, as specified in Appendix B, located at a range of 100 nm and separated by three degrees in azimuth. Strobe processing shall report interference amplitude levels in eight equal steps of 8 dB from the receiver noise level to the receiver limit level. Strobe processing shall also report the approximate elevation angle in one degree increments from -1.0/+0.2 to 20 degrees. The ARSR-4 shall be capable of analyzing the strobes on a scan to scan basis in such a manner as to eliminate false strobe reports. Additionally, an analog strobe video shall be available at the LDC and the LDCs demarcation point as specified in 3.5.16.

3.5.9 Beacon Target Processor.-

3.5.9.1 Initial Functions.-

The overall capabilities and functions of the BTP shall be as described in the following subparagraphs.

3.5.9.1.1 Target Processing.-

The BTP shall receive antenna azimuth data, beacon mode and timing signals, beacon video, test video, and test indicators. The BTP shall provide means for bracket detection, code extraction, reply degarbling, and timing. The processor shall perform all of the processing necessary to provide completed beacon target reports to the system. All of the operational and self-test functions of the processor shall be controlled by the appropriate software. Functions of the processor will be implemented in firmware.

3.5.9.1.6 BTP Timing.- The BTP shall provide a means of associating the correct range and azimuth data with each reply detected and reported in the BTP. The BTP shall provide appropriate range clock generation. The clock's frequency shall be such that an integral number of clock pulses occur in the nominal video code pulse interval of 1.45 μsec and bracket interval of 20.3 μsec. The least significant bit of the range word used for the bracket detection reply shall be no greater than 125 nsec. The leading edge of the P3 pulse of the beacon mode trigger shall define beacon zero range. All time or range manipulations in the BTP shall use the BTP range clock or multiples thereof. The conversion of range to nautical miles for a target report shall be performed in the BTP. A BTP range alarm shall be indicated if the clock fails or changes frequency such that the design value number of clock intervals yields a value more than 20 nsec from the correct bracket spacing of 20.3 μsec.

The BTP shall also decode the mode trigger pulse spacings for Modes 2, 3/A, and C in any interlace sequence and provide the appropriate mode data in the BTP. If an illegal or out-of-tolerance pulse spacing is received or if the P3 pulse fails or is more than 2.0 μsec from its expected position, a mode trigger alarm shall be indicated in the BTP.

The BTP shall contain appropriate azimuth word generation circuitry. The input data shall be in the form of IACP data (16,384 IACPs per ARP). Thus, the least significant bit in the azimuth word shall be 0.022 degree. All azimuth manipulations in the BTP shall use this azimuth reference and position granularity. A BTP azimuth alarm shall be indicated if there are not exactly 16,384 IACPs per ARP.

The BTP shall report data to the search/beacon reinforcement function for target reinforcement processing. If the transfer is incomplete or the search/beacon reinforcement function cannot accept the reply data within the time necessary to meet the performance requirements established elsewhere, a BTP output alarm shall be indicated. This alarm, in particular, shall not depend solely on the data transmission technique for its transfer to the search/beacon reinforcement function. Similarly, if the BTP loses data because of any register or buffer overflow due to conditions external or internal to the BTP, a BTP overflow alarm shall be indicated.

For a BTP with a range clock period outside of the 85 to 125 nsec interval, the tolerances shall be as follows with respect to 20.3 μsec:

Tolerance Setting	Acceptance	Rejection
+/-100 nsec	+/-0.1 μsec	+/-250 nsec
+/-200 nsec	+/-0.2 μsec	+/-375 nsec
+/-300 nsec	+/-0.3 μsec	+/-500 nsec

The bracket detection logic shall recognize and inhibit the false bracket detection output that could otherwise occur because of the presence of the C2 and SPI pulses in a reply train. Detection of a valid bracket pair shall cause the sampling of the data in the mode, range, and azimuth registers for use in the code extraction and garble sensing circuits, and for inclusion in the BTP's output reply word. Bracket detection information shall also be provided to the RMM for tabulating and display.

3.5.9.1.4 Code Extraction.- The sensing of the beacon framing pulses shall cause the sampling of all of the information pulses which may be associated with the reply. The nominal positions and pulsewidths of the 13 code pulses and the SPI pulse will be as specified in attachment 1 to FAA Order 1010.51A. The particular reference used for each individual bracket detection (3.5.9.1.3) shall be used to establish the nominal sampling positions of the information pulses associated with that bracket. Regardless of the reference used, the sampling shall be accomplished using the same tolerances as specified for bracket detection, except that there shall be only two selectable for the code data sampling tolerance: +/-0.1 μsec and +/-0.2 μsec. The sampling technique shall not necessarily require a leading edge to detect a code pulse. The selection of the code data tolerance shall be accomplished by simple internal means and shall be separate from those of bracket detection or garble sensing.

3.5.9.1.5 Garble Sensing.- The BTP shall check the bracket and code data for garble conditions that may exist which would interfere with the target detection and code validation processes. Interleaved replies are, by definition, not mutually interfering and shall not cause a garble declaration regardless of the extent of the interleave. Similarly, closely-spaced replies do not mutually interfere. Therefore, all replies involved in an interleaved or a closely-spaced reply condition, or a combination thereof, shall be correctly and unambiguously decoded and processed without garbling. The BTP shall recognize the false, "phantom" brackets which can occur in the closely-spaced reply condition when nonframing pulses in different replies occur at the framing interval. All such phantom brackets shall be detected and eliminated without garbling or otherwise affecting the correct replies. The information data associated with overlapped replies which cannot be unambiguously resolved shall be destroyed (set to all zeros) and a garble flag set in the associated reply word. The bracket detections of the overlapped replies shall remain intact and shall be available for use in the target detection process.

3.5.9.1.8 Code Validation.- The BTP shall attempt to validate the ungarbled Modes 2, 3/A, and C codes, including SPI, X, and military emergency bits which are correlated with a target during the target detection process. The validation process shall start with the second reply received for a target regardless of whether or not that reply's sweep is a detection sweep. Except as noted in 3.5.9.1.9, a data code shall be validated if, during the target detection process, Vc or more consecutive ungarbled replies to the same interrogation mode identically compare on a bit-for-bit basis, where Vc is the validation count. The value of Vc shall be field adjustable from less than two to at least six in unit increments. The validation process shall be conducted separately, and shall set separate code-valid flags, for the following code bits: 12-bit Mode 2, 12-bit Mode 3, 12-bit Mode C, SPI, Mode 2's X-bit, Mode 3's X-bit, and the military emergency bit. If the validation attempt is not successful, the appropriate code-valid flag shall remain not set and, in the cases of the three 12-bit codes only, the value last received before the completion of the target detection process shall be included in the output target report. If, during the entire runlength of a target, no ungarbled replies are received for a given mode, then the appropriate code bits shall be set to all zeros and the appropriate code-valid flag shall remain not set. In all other instances, the validated code or codes shall appear in the target report. Upon successful completion of the validation process, the incoming code data shall continue to be inspected and utilized by the target detection process to resolve any adjacent targets.

3.5.9.1.9 Code Transformation.- After validation and before entering the target report into the output buffer, the BTP shall transform the Mode 3/A, Mode C, and Mode 2 code data from the aircraft reply format to the digital message format. The Mode 3/A reply grouping of C-A-B-D shall be transformed to the binary-coded-decimal format of A-B-C-D, as specified for the beacon output message [3.5.13(h)]. When the military emergency bit is validated, the aircraft's Mode 3/A code shall be replaced with code 7700 and the Mode 3/A validation flag shall be set. The Mode C reply grouping of C-A-B-D shall be transformed to the appropriate 12-bit 2's compliment binary code indicating the aircraft's reported pressure altitude. Refer to Attachment 1 to FAA Order 1010.51A and 3.5.13(h) herein for additional Mode C conversion requirements. Illegal or undefined Mode C reply codes shall be reported without the Mode C validation flag being set, even if they otherwise meet the validation criterion. The Mode 2 reply data shall be rotated one bit to the right such that it conforms with the format of 3.5.13(h).

3.5.9.1.7 Target Detection.- The BTP shall accept bracket declarations, ungarbled code replies, and appropriate status flag and timing data for use in target declaration. The beacon reply data shall be compared in range, azimuth, and code with previously received replies such that all Modes 2, 3/A, and C replies from a single aircraft are grouped into a single target file. No beacon reply shall be correlated with, or used in formulating, more than a single target report. If a choice of targets exists for a given reply, the reply shall be correlated with the most similar target file, and the special beacon target indicator flags shall be set in all target files considered for such correlation. Each beacon reply that fails to correlate with an existing target file shall cause the formation of an initial target file. The correlation criteria shall be a fixed software function of the detection algorithm and shall not be accessible to operation or maintenance personnel. Replies from only Modes 3/A, 2, C or all or any combination shall be used in the beacon target detection process; selection shall be site adjustable.

The specific detection algorithm implemented in the BTP shall be either a sliding window or, at the contractor's option, a type of sequential observer. The algorithm shall use a fixed range cell technique for allocation of reply range data or, optionally, a floating range cell technique. The algorithm shall, however, be chosen and implemented in such a manner as to meet or exceed the accuracy, resolution, split and false target rates, and Pd requirements specified in 3.4.2 under any permissible combination of radar and aircraft conditions as specified in 3.4.1.8 and 3.4.2.4. Other algorithms for target detection may be utilized if it can be demonstrated that it meets of exceeds the requirements. The selected technique shall be able to resolve and correctly report at least four stationary, interleaved targets where the F2 pulses of the furthermost replies occur less than 3.0 nm after the SPI position of the first target's replies. Any embellishment to the basic target detection algorithm which is required to meet these requirements shall be provided. All fixed parameters necessary to optimize the detector for a reply situation, including the leading and trailing edge criteria and, in the case of the sliding window algorithm, the window length, shall be field adjustable.

3.5.9.1.10 Target Position Bias Correction.- The BTP shall provide for the correction of the position of all beacon targets to eliminate any positional bias errors introduced by the target detection process. This correction shall be a software parameter which is not subject to operator control. It shall be a single fixed value, unless the selected target detection algorithm requires a dynamic correction technique to meet the established performance requirements. In the latter instance, the dynamic correction shall be implemented in such a manner that it can be easily modified at such time as the target detection algorithm is modified. The BTP shall also transform the target's range to nautical miles as a part of this bias correction process. A site adjustable azimuth correction shall be made available to compensate for azimuth errors induced by a search/beacon antenna misalignment and mode interlace.

In addition to this correction, a separate means of inserting range corrections shall be site adjustable to offset any range errors caused by search-to-beacon radar timing or other sources of error which may exist external to the BTP. This correction is in addition to similar adjustments required elsewhere and shall not invalidate the accuracies of internally generated beacon test targets. The range correction shall provide for biasing the target report range from zero to at least 5.0 nm in either direction from the nominal target position in increments of 1/32 nm or less.

3.5.9.1.11 Runlength Processing.- The BTP shall be able to inhibit beacon targets which have unacceptable runlengths and output those which are of an acceptable runlength. An acceptable beacon target is one which consists of no fewer than the minimum beacon runlength replies nor more than the maximum beacon runlength replies, where minimum beacon runlength indicates a short runlength threshold for beacon targets and maximum beacon runlength is the long runlength threshold. A target file which does not contain at least the minimum beacon runlength correlated replies or which contains more than the maximum beacon runlength correlated replies shall not result in a final target report. The values of maximum beacon runlength and minimum beacon runlength shall be able to be independently set by a field adjustment in each of at least 16 independently established range and azimuth sectors. Minimum beacon runlength shall be variable from zero to at least 15 and maximum beacon runlength shall be variable from less than eight to at least 100 in integer values.

The start-stop range and azimuth values for each sector shall be able to be independently set anywhere in the BTP's coverage with a resolution of 0.7 degree and 0.5 nm or better. Each sector shall be able to provide full azimuthal coverage (360 degrees). The control of the sectors' values for minimum beacon runlength and maximum beacon runlength shall be field adjustable. This runlength discrimination feature shall be enabled or disabled by field adjustment and shall not apply to beacon strobe or beacon Real-Time Quality Control (RTQC) test targets.

In addition to the runlength discrimination, the BTP shall convert the runlength information from the number of replies which make up the report, to the azimuth extent over which those replies were received. This azimuth runlength shall be provided for all BTP output target and strobe reports and shall have a Least Significant Bit (LSB) of 0.088 degree and a Most Significant Bit (MSB) of 22.5 degrees. As indicated in 3.5.13(h), the runlength is always reported in the common format strobe message, but it must displace other bits in the beacon message because of message capacity limitations. Accordingly, the BTP shall, by field adjustment, set or reset a beacon runlength reporting flag in each BTP output target report. This flag shall then be used to initiate insertion of the azimuth runlength data in the common format beacon messages. When beacon runlength reporting is enabled, a conspicuous notation to that effect shall be displayed on the RMM to alert the personnel to this nonstandard condition.

3.5.9.1.12 Strobe Processing.- The BTP shall count the number of bracket declarations each sweep and compare them to a field adjustable threshold. When the threshold is exceeded, the processing of all new bracket detections shall be inhibited for the remainder of that sweep while any in-process targets shall continue to be processed and reported out normally. Normal inputs to the targets shall resume after an additional complete radar sweep with fewer brackets than the strobe threshold has passed and been observed. For each sweep or portion thereof in which normal inputs to the target detector are inhibited, an artificial bracket detection pulse shall be inserted into the target detector with a pseudo range of 254.5 nm. The normal beacon target detection algorithm shall apply to this pseudo target except that every sweep with a strobe declaration shall be used in the detection algorithm, regardless of the mode interlace. Any resulting beacon strobe target shall be reported as specified in 3.5.9.1.16 with the pseudo range of 254.5 nm, and the detected center azimuth and runlength.

The beacon strobe elimination feature shall be able to be enabled or disabled by field adjustment. The threshold for activating the strobe elimination feature shall be site adjustable in increments of 16 from zero to at least 512.

3.5.9.1.13 Processing Range.- The BTP shall be able to inhibit the reporting of beacon targets which are not within a site-selectable range coverage. The beacon minimum range shall be variable from zero to at least 32 nm and the beacon maximum range shall be variable from zero to the maximum BTP range of 250 nm. The values shall be site adjustable in increments of 0.5 nm or less. Neither function shall affect the reporting of beacon strobe, RTQC, or self-test targets.

3.5.9.1.14 Beacon Offset.- The BTP shall be able to offset the range of beacon targets to allow the collection of both search and beacon target data from aircraft returns. The offset shall add 0.50 nm to the otherwise correct range of all beacon targets except those generated internally for the RTQC (3.5.15.8.4.1). The offset enable/disable shall be field adjustable. When the offset is enabled, a conspicuous notation to that effect shall be displayed on the LDC monitor, and the condition shall be reported in the BTP status report.

3.5.9.1.15 Special Military Replies.- Certain military transponders indicate emergency and identification conditions with special reply formats. These special military responses to Mode 3/A interrogations are defined and shall be processed as specified below:

(a)   In lieu of the civilian transponder's single emergency (code 7700) reply, some military transponders will transmit four complete reply pulse trains, with the first framing pulse of the succeeding reply trains occupying the SPI pulse position of the preceding pulse train. The emergency code of 7700, if it is transmitted at all, may appear in the first reply train with either the normal Mode 3/A code or an all-zero code in the remaining trains. The BTP shall recognize this reply format even if the second or third reply train (but not both) is missing, and shall report it to the BTP as a single reply with a military emergency flag bit set. The BTP output shall include the range, azimuth, and code of the first reply train only.

3.5.9.1.16 Target Message Content.- The BTP shall provide output data for the search/beacon reinforcement function. The beacon target report, beacon strobe report, BTP status report, and Mode 4 messages shall be provided by the BTP. The messages must contain at least the following information and that called out for in 3.5.13(h).

(a)   Target Report:

(1)   RTQC - A unique message which identifies the beacon RTQC test target.

(2)   Test - A unique message which identifies if the test indicator was present for one or more of the target's replies.

(3)   Message label - A unique bit arrangement which identifies the message as a BTP output target report.

(4)   Code validation and emergency flags - Six code validation flags (Mode 2, Mode 2"X", Mode 3/A, Mode 3/A"X", Mode C, and Identification or SPI) shall be identified by unique messages upon successful completion of their respective validation processes. The presence of validated 7600 or 7700 Mode 3/A emergency codes shall be identified by unique messages.

(5)   User bits - A unique bit arrangement which identifies the FAA and Air Force in each beacon target report.

(6)   Range - A unique message which identifies the average range of the individual replies which make up this report. The range shall be reported from LSB 1/32 nm to MSB 128 nm.

(7)   Special target - A unique message which identifies a special beacon target indication as specified in 3.5.9.1.7

(8)   Azimuth - A unique message which identifies the average azimuth of the individual replies which make up this report. The azimuth shall be reported from LSB 0.022 degree to MSB 180 degrees.

(9)   Discrete - A unique message which identifies whenever the report contains a discrete Mode 3/A code.

(10)   Runlength flag and data - A unique message which identifies the azimuth runlength of the target as specified in 3.5.9.1.11.

(11)   Code data for Modes 2, 3/A, 4, and C - A unique message which identifies the validated or invalidated code data of the target. Also, a unique message which identifies if a particular mode was not interrogated or if the aircraft did not reply, was garbled, or replied with framing pulses only to Mode 2 or Mode 3/A interrogations shall be transmitted.

(b)   Strobe Report

(1)   Test - A unique message which identifies if the test indicator was present for one or more of the target's replies.

(2)   Message label - A unique bit arrangement which identifies the message as a BTP output strobe report.

(3)   User bits - A unique bit arrangement which identifies the FAA and Air Force in each beacon strobe report.

(4)   Range - A unique message which identifies the range of the beacon strobe report as specified in 3.5.9.1.12. The range shall be reported at 254.5 nm using the same range LSB and MSB as the beacon message.

(5)   Azimuth - A unique message which identifies the average azimuth of the individual replies which make up this report. The azimuth shall be reported using the same LSB and MSB as the beacon message.

(6)   Runlength data - A unique message which identifies the azimuth runlength of the strobe as specified in 3.5.9.1.12.

(c)   Status Report- Unique bit arrangements indicating each of the following BTP status conditions shall be provided by the BTP:

(1)   BTP Range alarm

(2)   BTP Azimuth alarm

(3)   BTP Output alarm

(4)   BTP Overflow alarm

(5)   Beacon mode trigger alarm

(6)   Results of the operational self-test

(7)   Beacon offset

(8)   Beacon runlength reporting

(9)   Beacon runlength discrimination status on/off

3.5.9.1.17 Mode Interlace Sequence.- The beacon mode interrogation sequence employed in the ARSR-4 shall normally be Modes 3/A, 2, 3/A, C. For this interlace sequence, the primary mode is Mode 3/A. All beacon and beacon reinforced search performance requirements specified herein shall be achieved using this beacon mode interlace pattern. The interlace pattern shall normally be established via switch action at the ATCBI-5. When the interlace sequence of the ATCBI-5 is changed, an azimuth shift will occur. The ARSR-4 shall have a site adjustable feature compensating for any changes resulting from an interlace sequence change.

3.5.10 Beacon/Search Reinforcement Function.- The beacon/search reinforcement function shall reinforce the separate beacon and search target reports (3.4.1.8 and 3.4.2.4) which result when the same aircraft target is detected by search target extraction and the beacon target processor. The reinforcement shall be accomplished such that a unique target message for a beacon reinforced search target is reported for a single aircraft which is detected by both radar systems. The reinforcement algorithm shall reinforce only those targets which meet established range, azimuth and altitude criteria. These criteria shall be initially determined by the contractor and approved by the Contracting Officer prior to the start of equipment production. The selected criteria shall be field adjustable. When the beacon report is offset 0.5 nm in range (3.5.9.1.14) beacon/search reinforcement shall not occur. The beacon/search reinforcement message shall contain either the range and azimuth of the beacon target, the range and azimuth of the search target, the search range and beacon azimuth, or the beacon range and the search azimuth. The selection of the data source for the position report shall be field adjustable. A single target which is detected by both radars shall be reported as a single reinforced beacon message at least 99.9 percent of the time. The reinforced beacon/search targets, unreinforced search targets, and unreinforced beacon targets shall be forwarded to the editor function.

3.5.11 Scan to Scan Correlation.- Scan to scan correlation shall be continuously performed on the data from the search target extraction function. The scan to scan correlation shall use tracking algorithms to accomplish two functions. The output of the first function shall be used to meet the detection requirements of 3.4.1.2 and the false report requirements of 3.4.1.6 and shall provide data to the BTP or Mode S reinforcement function. The output of the second function shall be used to reduce the false report rate to 10 percent or less of that at the output of the first function when the first function is adjusted for 25 knots. The second function shall provide data to the editor.

The first function shall eliminate reports having ground velocities up to 25 knots (to be field adjustable from 0 to 80 knots). For this function all initial target reports shall be outputted on each scan. Targets are only to be deleted when they are in track and determined to be less than 25 knots ground velocity. Since this function is performed on all data, it is, therefore, to be considered in meeting the false reports requirements of 3.4.1.6 when adjusted to 25 knots.

The second function shall use tracking algorithms to edit the reports to be able to output only those reports that have scan to scan position expected of aircraft. The second function shall not track targets less than or equal to 25 knots (field adjustable from 0 to 80 knots, but not required to be less than the first function's adjusted velocity). The purpose of this function is to reduce the false reports below that specified in 3.4.1.6. It is not a consideration in meeting the specified false report rate of 3.4.1.6. Ground velocities for aircraft tracking may be stratified by altitude. If altitude data is used, it shall be that obtained from the search reports. The altitude strata versus ground velocities for the purpose of this tracking function only are as follows:

(a) Surface to 10,000 ft.   25 to 300 Knots

(b) 10,000 ft. to 50,000 ft.   25 to 700 Knots

Returns above 50,000 ft. shall be outputted from the second function without using a tracking algorithm. Altitude errors and aircraft climb and descent rates shall be considered in using altitude data at the 10,000 ft. and 50,000 ft. altitude boundaries to assure that aircraft are not dropped from the tracking algorithm because consecutive returns from the same aircraft cross either of these boundaries.

It shall be possible by field adjustment to alter each altitude stratum, in 1,000 ft. increments, and its associated velocity, in 10 knot increment and to adjust the tracking algorithm to accommodate this alteration.

For the second function, only the reported position of targets shall be forwarded (i.e., no smoothed or coasted positions are to be outputted). Under this condition the Pd specified for the various environments specified in 3.4.1.2 shall be met after the target has been detected any 3 out of 5 successive scans. To meet this requirement in angel clutter, the 25 knot threshold of the second function may be raised to a maximum of 60 knots when angel clutter conditions exist. For the purpose of meeting the specified Pd and false report requirements, the tracking algorithm must accommodate turn rates of 6 degrees per second for aircraft with ground velocities of 200 knots or less and 3 degrees per second for aircraft with ground velocities greater than 200 knots.

The various tracking criteria used by the tracking function shall be field adjustable, so as to be able to optimize its performance under differing field conditions.

3.5.11.1 Editor.- The potential target reports that do not reinforce with beacon target reports and are returned from the beacon reinforcement process must be outputted directly from the editor as first function radar only target reports and compared with the output from the scan to scan correlation second function to generate a single target report for each radar-only target from the second function. This shall be accomplished by the functional block named "Editor" referenced in Figures 3-2 and 3-3. The editor shall compare the targets returned from the beacon reinforcement function with the output of the scan to scan correlation second function. A radar-only target report shall be generated only when the target appears in both the reinforcement function output as a radar-only and the output from scan to scan correlation second function. These reports shall be provided to the formatter (3.5.13) along with beacon only and beacon/search reinforced data for output transmission. The following four data features shall be provided at the output of the formatter for the selection of radar-only reports and shall be available to all users through field selection.

(a) First function scan to scan correlated data.

(b) Edited second function scan to scan correlated data.

(c) Edited first function scan to scan correlated data which has three field selectable sectors adjustable in range and azimuth in one nm and one degree increments over the entire coverage volume. The data in those selected sectors shall be data from the second function of the scan to scan correlation function. This feature shall be reversible so that the data from the edited second function of scan to scan correlation has three field selectable sectors adjustable in range and azimuth in one nm and one degree increments over the entire coverage volume. The data in those selected sectors shall be data from the first function of the scan to scan correlation function.

(d) This data feature is the same as (c) above, but totally independent from (c) above. The selection of edited first or second function data and the three field selectable sector adjustments shall be capable of producing another separate and distinct data feature from (c) above.

3.5.12 Weather Data Subsystem.- A weather processing capability shall be provided to report three levels of weather data from five possible levels of weather intensities that are field selectable. Provisions shall be provided to allow reporting of all five levels of weather intensities if and when an expanded weather reporting capability is implemented (3.5.16.15). The transmit waveform for the weather data may be the same one as used for the aircraft target detection or may be a separate transmit waveform as determined by the contractor to meet the specified requirements. The antenna subsystem shall be that used for the aircraft target detection. The contractor shall provide the ability to measure the reflected energy from precipitation that is within line-of-sight of the radar and 2,000 or more feet Above Ground Level (AGL) and in a manner to minimize ground clutter contamination of the weather data.

3.5.12.1 Antenna Polarization.- In the event that the contractor's design uses circular polarization to reduce the precipitation clutter for aircraft target detection purposes, the antenna output for weather processing shall be the opposite sense polarization during any time that the circular polarization is in use.

3.5.12.2 Weather Receiving Characteristics.- The receiver(s) shall have sufficient sensitivity, dynamic range and linearity to support the processor's capability to produce the five levels of weather data corresponding to the standard National Weather Service (NWS) values (i.e., levels 2 through 6 are; ≥ 30 dBZ, ≥ 41 dBZ, ≥ 46 dBZ, ≥ 50 dBZ, and ≥ 57 dBZ) and to permit the processing of weather in ground clutter areas as discussed in 3.5.12.3. In the event that the contractor elects to use the receiver(s) used for the aircraft detection to provide data to the weather processing function, all performance requirements for weather and aircraft detection and false reports shall be met simultaneously.

3.5.12.2.1 Radar Remote Weather Display System (RRWDS) Output.- A separate video weather output shall be provided for use by the RRWDS digitizer. This output shall be taken following the clutter suppression and mapping functions specified in 3.5.12.3.1, with conversion to analog log video being provided. The analog log video output shall be in a form that will permit the RRWDS digitizer to accurately threshold to the five weather data levels corresponding to the standard NWS values. Ground clutter processing is required for this output. The analog log video output shall be normalized to a R^{-4} gain correction. The interface requirements for the RRWDS are defined in 3.5.19.

3.5.12.3 Weather Processor.- The Weather Processor (WP) shall perform three functions.

(a) The separation of weather returns from ground clutter.

(b) The sampling and thresholding of the weather at any of three selectable weather levels of the aforementioned five NWS levels.

(c) The reporting of the weather in a method compatible with the ARTCC message format.

The WP shall be capable of distinguishing between weather returns and jamming signals. It shall not report jamming as weather.

3.5.12.3.1 WP Ground Clutter Suppression.- The WP ground or sea clutter suppression shall provide the capability for measuring weather parameters in the presence of ground and sea clutter. It shall address the following clutter levels so as to maximize the weather reporting accuracy when competing with these environments:

(a) σ_o <-20dB ground clutter for mountains

(b) σ_o <-23dB ground clutter for wooded hills

(c) σ_o <-28dB, 34dB, and 45dB ground clutter for lowlands with grazing angles of 5, 1, and 0.1 degrees, respectively, for the 10 knot spectral density curve of Figure A3 in Appendix A.

(d) σ_o <n_x for sea state 5 (Table A4 in Appendix A)

For cells exceeding the levels specified above, fixed map censoring shall be provided. A capability shall be provided to alter this fixed map censoring by a field adjustment.

3.5.12.3.2 Weather Averaging and Thresholding.- The WP shall average the weather data in both range and azimuth so as to provide the overall accuracy required and minimize isolated aircraft or point targets and to eliminate isolated missing data points from a contiguous stream of data. The averaging shall take place over a symmetrical sliding range block of not more than one nm in range and over one beamwidth in azimuth. The average weather data shall be calculated once every 0.25 nm. The average intensity estimates for each 0.25 nm shall be compared to five thresholds corresponding to standard NWS weather levels 2, 3, 4, 5 and 6, over the range interval from 5 nm to 200 nm. The overall accuracy of the measured weather at each threshold shall be within +/-2dB for levels 2 through 6 from 5 to 160 nm and for levels that exceed 10 dB weather to noise ratio from 160 to 200 nm. The clutter model parameters for weather (Appendix A) shall be used to establish the extent of beam filling at each location for actual site elevation and latitude environment for areas free of ground clutter. This accuracy requirement shall be met taking into consideration all system errors. Errors induced by the specified ground clutter suppression and clutter residue shall be considered acceptable. An automatic calibration technique shall be provided to maintain the specified accuracy in the event that system parameters vary over time. The system must maintain its accuracy with any combination of transmit waveforms that may be used.

3.5.12.3.3 Weather Data Reporting.- For reporting purposes the three thresholds (referenced to the NWS levels) selected shall be referred to as A, B, and C, with A being the threshold for the lowest weather level, B and C the higher threshold levels. Weather data output shall be transmitted every scan or on alternate scans. The data shall be able to be interlaced such that all of the messages for a given threshold's data are transmitted in a single scan, or are uniformly divided in azimuth over three antenna scans. The reported thresholds shall be independently field selectable. Thus, it shall be possible to configure the WP to report thresholds A, B and C on an alternate scan scheme with the three scan interlace as follows: 0A0A0A0B0B0B0C0C0C where "0" indicates that no weather data was transmitted on that scan; and the letters A, B and C indicate the three scans required to transmit the complete azimuth-interlaced contour data for each threshold. This interlace requires 18 antenna scans to completely transmit the weather data. A continuous report of a 3-scan interlace scheme of these same thresholds would be AAABBBCCC. This interlace requires nine antenna scans to completely transmit the weather data. The control of interlace, continuous or alternate scan reporting, and selection of reportable thresholds shall be field selectable.

The WP shall provide for improved azimuth reporting intervals at longer ranges to maintain an approximately constant azimuth reporting density over the entire coverage area of the radar display. Two such reporting intervals shall be available for each of the three reported thresholds. Selection of the low or high interval for each of the three reported thresholds, referenced to the NWS levels, shall be field adjustable. The spacing between adjacent report azimuths as a function of report range shall be as follows:

Range (nm)	High Interval* (degrees)	Low Interval* (degrees)
5 - 40	5.6	2.8
40 - 80	2.8	1.4
80 - 136	1.4	0.7
136 - 250	0.7	0.35

* Azimuth reporting interval relates to the output format for display purposes only.

The processor shall compare separately for each threshold level selected to be reported the threshold outputs within one-half the azimuth reporting interval on either side of a given report azimuth. For each block of weather the shortest range of each threshold output within the azimuth reporting interval shall be used as the start range for the weather message for the associated report azimuth. Similarly, the longest range of each threshold output within the azimuth reporting interval shall be used as the stop range for the weather message for the associated report azimuth.

3.5.12.3.3.1 Weather Range Discrimination.- The WP shall include a weather range discrimination function which inhibits the reporting of those areas between adjacent weather cells which are smaller in range than a selected value. If, for a reportable azimuth, two or more separate weather cells are detected such that the start range of the cell at the greater distance occurs within a selected range interval of the stop range of the closer cell, the stop range of the earlier cell and the start range of the later cell shall be ignored and the greater stop range used in the reported message. These operations shall be able to be chained together over the full weather contouring range to permit the reporting of a storm with small holes (in the range dimension) as a single block of weather. The discrimination value shall be variable from zero to at least 15.5 nm in 0.5 nm increments, and shall be field adjustable.

3.5.12.3.3.2 Weather Contouring Range.- The WP shall be able to modify the start range of the weather message to reflect the detected weather start range or a weather minimum range, whichever value is greater. Similarly, the stop range shall reflect the detected weather stop range or a weather maximum range, whichever is the smaller. The weather minimum contouring range shall be field adjustable from 5 nm to at least 32 nm in increments of 1.0 nm or less. The weather maximum contouring range shall be field adjustable from 5 nm to the maximum processing range of 250 nm in increments of 1.0 nm or less.

3.5.12.3.3.3 Weather Processor Output.- The output of the WP shall feed the formatter (3.5.13). An analog log video output shall be provided for the RRWDS per 3.5.12.2.1 and 3.5.19.

3.5.13 Output Interface Message Formatting.- The ARSR-4 is required to interface with several users simultaneously, each with a different message format. Figure 3-4 is a simplified example of what could occur during the transition from the current ARTCCs to Area Control Facilities (ACFs). Other centers and other users (USAF, United States Navy (USN), customs, etc.) shall be receiving data at the same time. For illustration purposes, only 13 of the 20 required ports are shown in use, a port being a modem attachment point. A port, modem, and communications link form a data transmission channel.

When initially installed, the ARSR-4 will be "plug compatible" with the current ARTCC, SOCC, and U. S. Navy Fleet Area Control and Surveillance Facility (FACSFAC) interfaces. This requires that the ARSR-4 output format be equivalent to the CD-2 output format [3.5.13(h)]. An extended CD-2 format will be used for the military user outputs to accommodate the height data. As the FAA National Airspace System evolves, and the Advanced Automation System is installed, the format for messages being transmitted to the ACF will be modified as specified in 3.5.13.4 herein.

All DOD user interfaces will be identical. Additionally, all DOD users will have the USAF USER bit set.

A message formatting function, which will also be referred to as the formatter herein, shall be provided for each ARSR-4. The formatter shall provide all of the following features as a minimum.

    (a)   Provide message data in digital form to modems operating at 2,400 to 56,000 bits per second (bps). Each port shall be capable of asynchronous and synchronous operation
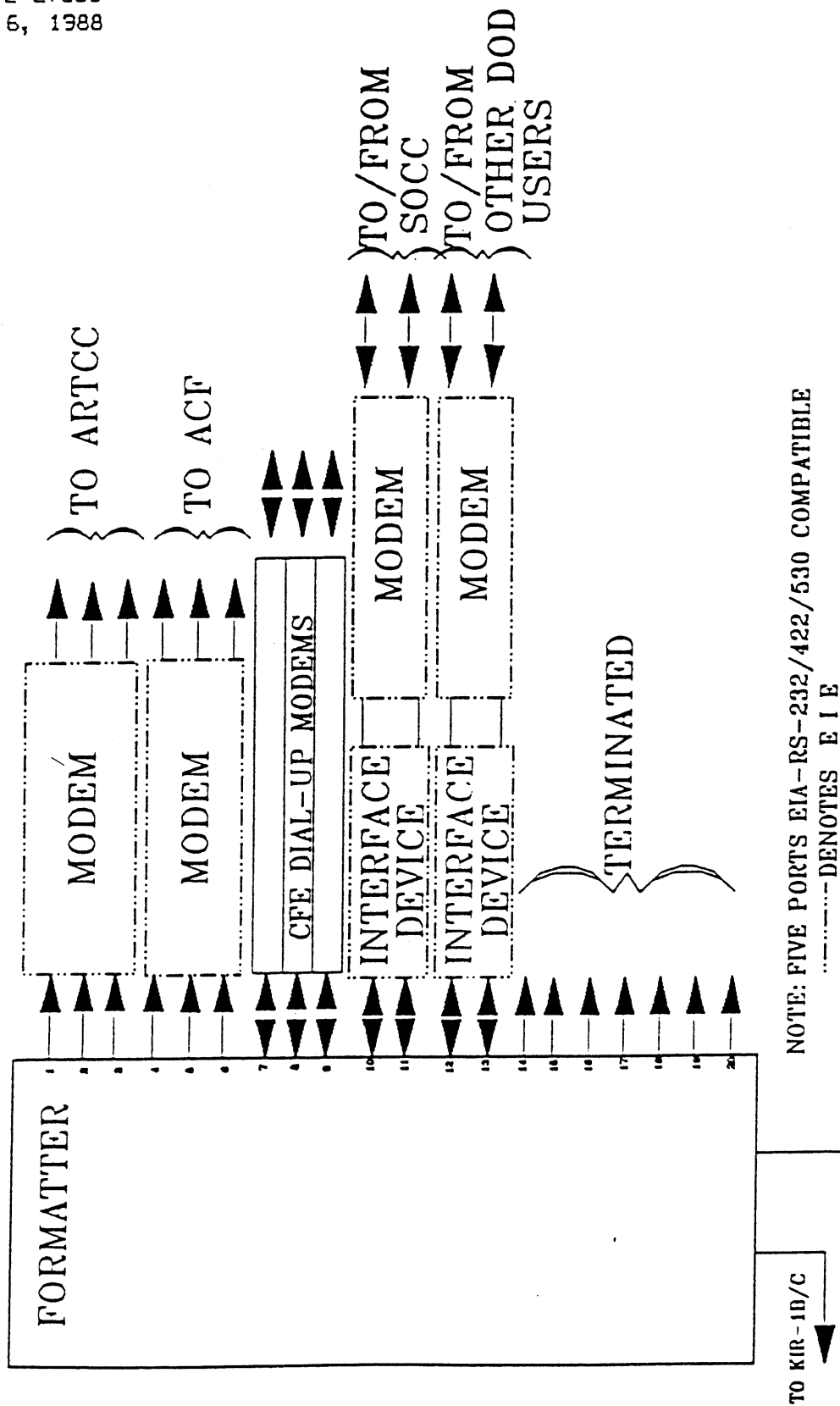
Figure 3-4, OUTPUT INTERFACE

NOTE: FIVE PORTS EIA-RS-232/422/530 COMPATIBLE

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(b) Provide a minimum of twenty (20) output ports, each one capable of being independently programmable (site selectable/adjustable) in such a manner as to allow any or all ARSR-4 data products (excluding RMS data) to be outputted from each port (e.g., each transmission word independently structured so that any data can or cannot be sent to a particular user). Five of the 20 ports shall simultaneously be EIE-RS-232, EIA-RS-422, and EIA-RS-530 compatible as specified in 3.5.22. Nine of the ports shall be EIA-RS-232 compatible only, and six of the ports shall be EIA-RS-530 compatible only.

(c) Each port shall be capable of outputting messages consisting of words that are 13 bits to 16 bits long (e.g., so that the range word LSB can be changed from 1/4 nm increment to an LSB of 1/8 or 1/16 nm increment without changing the range word MSB). Additionally, each port shall be capable of outputting data in a format compatible with ADCCP per ANSI X3.66. The formatter shall be designed to process and output data messages with minimum lengths of 256 bits.

(d) The I/O characteristics of the interface device are per RS-530 (SR) with the ARSR-4 being defined as a DTE. Only the RS-530 ports, designated as military ports via FAPs, shall be capable of operation with the KG-84Cs. Each port shall be independently programmable to clock data out of the ARSR-4 at any rate from 2,400 to 56,000 bps in 200 bps increments. Clocks are always provided by EIE. Each port shall be capable of operation in full duplex with the KG-84C red interface connector.

(e) Each port shall be terminated when not in use and shall be isolated from all other ports so as not to contaminate other data to other users.

(f) The formatter shall be capable of paralleling up to 4 output ports for any user (one, two, three, or four ports to any user) in the event that the single channel rate is too slow for the amount of data to be transmitted. The data load shall be distributed evenly over the paralleled ports.

(g) The contractor shall supply three commercially available modems with 4800 bps automatic dial-up capability. The modems shall be connected to three formatter output ports for target data transmission to other facilities for coverage analysis. Data requests to these modems shall be inhibited and access (on-off) field selectable for system security. Provisions shall be made to bypass the dial-up feature if needed, and the modems shall be easily bypassed so that the output ports may be used as specified for the other 17 output ports.

(h)   The message content and format at the time of delivery shall be a
        modified version of the CD-2 message format (FAA-E-2679). The
        Government shall provide the contractor detailed message format
        information, on contractor's written request, 90 days prior to
        each system delivery. Design of the formatter shall permit
        independently programmable outputs at each port (e.g. ability to
        control the combination of data messages from each port) as
        specified in part (c) above, and the ability to change the
        individual word (or field) format and size shall be provided. All
        digital data produced in the ARSR-4 shall be available at any
        output port through reprogramming action. The contractor shall
        provide stringent controls prohibiting unauthorized access to
        classified data via the message formatter and RMS.

(i)   Delay requirements specified in paragraph 3.4.1.14 and software
        spare requirements specified in paragraph 3.11.10 shall be met
        assuming eight users as described below:

        (1)   Two ACF users with three ports dedicated to each user and
               using the same SAMF format;

        (2)   One ARTCC user with three ports dedicated to this user and
               using the CD-2 format with weather data;

        (3)   Three military users with two ports dedicated to each user
               and using the CD-2 format without weather data and with the
               Military Map message;

        (4)   One weather user with the port dedicated to this user and
               the weather being reported in the CD-2 format;

        (5)   One additional user with three ports dedicated to this user
               and using the CD-2 format with weather data.

Additionally, it can be assumed that there are 12 military map sectors
enabled, three military target type filters enabled, three 15 degree Mode 4
inhibit sectors enabled, and that the three field selectable sectors described
in paragraph 3.5.11.1(c) and (d) are enabled.

3.5.13.1 Radar to SOCC Digital Radar Messages.- When initially installed,
digital radar messages transmitted from the ARSR-4 to the SOCC shall employ a
modified version of the format used by the FAA in transmitting radar data to
ARTCCs. This format and the message content for each format item is similar
to that specified in 3.5.13(h).

The output data provided to the ports assigned to the military shall consist of complete messages. In no instance shall a single message be split into parts and sent over more than one data channel. The messages are broken into 13-bit transmission words, each consisting of 12 data bits and an odd parity bit. The first transmission word in all messages contains special control flags and a message label that indicates the message type. Whenever valid message data are not being transmitted, successive idle messages are to be transmitted. This idle message is also transmitted between messages. The protocol, including parity and idle message generation, shall be the same for the military output data channels as for the FAA outputs. All USAF messages shall have the USAF users bit set. The formatter shall be capable of deleting all USAF messages by selected categories (search only, beacon only, or beacon/search reinforced messages) from transmission to the SOCC in three independent sectors, field adjustable and selectable in range and azimuth in one degree and one nm increments.

3.5.13.1.1 SOCC to Radar Request Messages.- Data requests from the SOCC to the ARSR-4 are Mode 4 interrogation requests and shall utilize the 91-bit message format specified in 3.5.13(h) at a 2,400 to 56,000 bps rate. The message content for each format item is similar to that specified in 3.5.13(h). When a Mode 4 interrogation request is not being transmitted, idle messages shall be continuously transmitted. An idle message will also be transmitted between each message of multiple requests. These messages shall be evaluated and the requests forwarded to the Mode 4 processing function.

3.5.13.1.2 Military Message Output Buffering and Modem Control.- The ARSR-4 message formatter shall regulate the processing of military messages so as to provide a free flow of each type of data through the formatter and interface device (3.5.20) to the USAF modems, regardless of the proportion of one type of data to another. Because of uneven distribution of aircraft population, more target reports will be generated at times than the transmission facilities can accommodate. Therefore, provisions shall be made for the future implementation of up to 56,000 bps modems. Accordingly, the formatter shall contain a military message output buffer for temporary storage of final reports and messages in the output format until one of the military output channels is ready to accept another message. The formatter military message output buffer shall use a modified first-in, first-out control algorithm such that all messages with a high priority are transferred from the buffer before any with a lower priority. USAF high priority messages shall be validated beacon emergency (codes 7500, 7600, or 7700) reports, military emergency, strobe reports, Mode 4 reports, and Mode 4 loop test. All other messages shall have lower priority. Separate military message buffer overload and overflow signals shall indicate when the buffer reaches approximately 75 percent and 98 percent of capacity, respectively. USAF map messages shall be prohibited from entering the queue when the overload condition is present, and all except status messages shall be inhibited during the military message overflow condition. The military message buffer shall be able to hold at least 500 common format messages in any proportion.

The ARSR-4 messages shall be available for transmission from the ARSR-4 1.5
seconds, as specified in 3.4.1.14, after the target enters the boresight of
the ARSR-4 transmission beam.   There will be times when the capacity of the
data channel will be insufficient to immediately forward all messages and a
queue build up in the output buffer will occur.   The military message buffer
control algorithm shall keep track of the length of time each message is in
the queue, using increments of 125 msec or less.   The Maximum Time-In-Storage
(TIS_{MAX}) value shall be field adjustable in increments of 125 msec or less
over a range of from less than 0.25 sec to at least 6.0 sec.   As each message
is readied for transfer from the buffer, the time spent in the queue shall be
calculated.   If this TIS is greater than the value TIS_{MAX}, the message shall
be declared as "old data."   Such messages shall not be transferred to the
interface device and modems nor shall they remain in the buffer.   The number
of these "old data" messages generated each scan shall be reported to the RMS.
If the TIS is equal to or less than TIS_{MAX}, the message shall be transferred
to the interface device and modem with the storage time appended as provided
for in the message format.

The formatter shall regulate the access of the USAF ports to the military
message output buffer memory.   Access shall be implemented such that the data
transmission rate of any USAF channel is not restricted by the formatter.   It
shall be possible to enable or disable any of the USAF ports through a field
selectable control.   The transfer of messages to the interface device and
modem, insertion of parity bits, idle message generation, bit output transfer
requirements, military message output service, and USAF modem alarm detection
functions in the formatter shall be the same as those specified in 3.5.13.2.1.
The formatter military message output service and modem alarms shall be
separately reported from those for FAA message output service and modem
alarms.

3.5.13.2   FAA Message Formats.- As delivered, digital radar messages
transmitted from the ARSR-4 to the ARTCC shall employ the format specified in
3.5.13(h).   Weather reports shall be transmitted in addition to these
messages.   The output data provided to the ports assigned to the FAA shall
consist of complete messages.   In no instance shall a single message be split
into parts and sent over more than one data channel.   The messages are broken
into 13-bit transmission words, each consisting of 12 data bits and an odd
parity bit.   The first transmission word in all messages shall contain special
control flags and a message label that indicates the message type.   Whenever
valid message data are not being transmitted, successive idle messages are
transmitted.   This idle message is also transmitted between messages.

3.5.13.2.1 FAA Message Output Buffering and Modem Control.- All messages provided to the ports assigned to the FAA shall have the FAA users bit set. Because of the uneven distribution of the aircraft population and weather echoes, more target reports and weather messages will be generated at times than the data transmission facilities can accommodate. Accordingly, the formatter shall contain an FAA message output buffer for temporary storage of final reports and messages until one of the FAA ports is ready to accept another message. The buffer shall use a modified first-in, first-out control algorithm such that all messages with a high priority are transferred from the buffer before any with a low priority. High priority FAA messages shall be validated beacon emergency (codes 7500, 7600 or 7700) reports, strobe reports, and search RTQC reports. All other messages shall have lower priority. The buffer shall be able to hold at least 500 common format messages in any proportion. Separate buffer overload and overflow signals shall indicate the status of the buffer.

The FAA message overload signal shall be generated by an algorithm that is a function of both the time it takes a message to transit the buffer (see TIS below) and the instantaneous quantity of messages in the queue. Other parameters such as message type shall be considered by the algorithm as well. This algorithm shall be designed to minimize the loss of beacon targets (as contrasted with other low priority targets) under high data generation/low output capacity conditions. The FAA message buffer overload and overflow signals shall indicate when the buffer reaches approximately 75 percent and 98 percent of its capacity, respectively. Map (weather) messages shall be prohibited from entering the queue when the overload condition is present, and all except status messages shall be inhibited during the FAA message overflow condition.

The ARSR-4 messages shall be available for transmission from the ARSR-4 1.5 seconds, as specified in 3.4.1.14, after the target enters the boresight of the ARSR-4 transmission beam. There will be times when the capacity of the data channel will be insufficient to immediately forward all messages and a queue build up in the output buffer will occur. The FAA message buffer control algorithm shall keep track of the length of time each message is in the queue, using increments of 125 msec or less. The TIS_{max} value shall be field adjustable in increments of 125 msec or less over a range of from less than 0.25 sec to at least 6.0 sec. As each message is readied for transfer from the buffer, the time spent in the queue shall be calculated. If this TIS is greater than the value TIS_{max}, the message shall be declared as "old data." Such messages shall not be transferred to the modems nor shall they remain in the buffer. The number of these "old data" messages generated each scan shall be reported to the RMS. If the TIS is equal to or less than TIS_{max}, the message shall be transferred to the FAA modem with the storage time appended as provided for in the common message format.

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The formatter shall regulate the access of each of the ports assigned to the FAA message output buffer memory. Access shall be implemented such that the data transmission rate of any FAA channels is not restricted by the ARSR-4 formatter. The throughput of the ARSR-4 formatter shall be limited only by the capacity of the data transmission equipment. It shall be possible to separately enable or disable any of the ports assigned to the FAA by field adjustment. A complete message shall be transferred from the FAA message output buffer to a temporary memory associated with an available FAA modem channel as controlled by the output buffer priority algorithm. An odd parity bit shall be inserted at the end of each field in the message before or during this transfer. The data bits shall be provided to the FAA modem as specified in 3.5.13(h). The even-parity idle message shall be transmitted once between successive messages on a given FAA output channel. It shall be transmitted continuously only if message data are not available for transmission. When more than one port assigned to the FAA is enabled and functioning correctly, the available FAA messages shall be divided evenly between the available outputs with respect to both message type and quantity, except that the ARSR-4 formatter's throughput shall not be degraded by this requirement.

A separate FAA message output service alarm shall be provided for each ARSR-4 port assigned to the FAA. It shall be set whenever that port has not transmitted a data bit in response to a modem clock pulse by the time of the trailing edge of that pulse, or when the port is otherwise operational, but cannot obtain a new message from the (nonempty) FAA message buffer within one field time. In the former instance, and also when an operational port assigned to the FAA is manually disabled or incapacitated by the failure of one or more modem clock signals, the message formatter shall generate an FAA modem alarm.

3.5.13.3 Not Used. –

3.5.13.4 Future Requirements.- The message format and content as described herein are those that will be required to interface with the ARTCCs and SOCCs when the ARSR-4 is delivered. As the FAA National Airspace System evolves, the ARSR-4 will be required to supply surveillance data to ACF containing the Advanced Automation System. This will require a change in the FAA message format. There will be periods of time when one ARSR-4 will be required to supply both the ARTCC and ACF, simultaneously.

3.5.13.4.1 Additional Memory and Processing Capacity.- In addition to the capacity included to meet formatting requirements herein, each ARSR-4 shall contain sufficient spare memory and processing capacity to simultaneously prepare and distribute messages for both the ARTCCs, as described herein, and the Area Control Facility. The Area Control Facility messages shall require at least 75 percent more bits than the ARTCC messages. If required, less than 10,000 Bytes from the additional storage capacity (3.11.10) may be used while the transition from the ARTCCs to ACFs occurs.

After Phase II testing, 100 percent of spare memory processing capacity shall remain unused in the ARSR-4. At the completion of Phase IV testing, each ARSR-4 shall have a minimum of 90 percent of spare memory remaining unused.

3.5.13.4.2 Future Message Contents.- The ARSR-4 shall provide surveillance data to the FAA's ACF and shall be in the Surveillance Advanced Message Format (SAMF) as defined in IRD NAS-IR-21013402, revised by IR 10039-001, when the ARSR-4 is interfaced with the ATCBI-5.

When the ARSR-4 is interfaced with the Mode S, the Mode S shall output all data to the ACF. The ARSR-4 shall provide to the Mode S all the surveillance data needed to meet the requirements of 3.5.18 herein and IRD NAS-IR-34060003. The outputs to the military users in the Mode S configuration shall remain as a function of the ARSR-4 formatter.

In addition to the aforementioned output message requirements, the ARSR-4 shall be capable of providing additional data to either the FAA users or Military users, or both to be used in future implementations. As a minimum, these shall include the following:

(a) Time of target reception referenced to the time of year clock.

(b) Doppler filter number (for each PRF), if available

(c)   Report Quality – Report quality is an estimate (on a scale of zero to seven) of the probability that the target report is not the result of system noise.

(d)   Report Confidence – Report confidence is an estimate (on a scale of zero to seven) of the probability that target report is the result of a true target.

(e)   Three (selectable) and five NWS levels of weather data with up to a twelve second update rate sent to the Mode S, which will be outputted to the ACF by Mode S; and sent to the ARSR-4 output message formatter for transmission to the ARTCC, during ACF/ARTCC transition, and possible other users needing weather data.

(f)   All other ARSR-4 generated data specified herein, where the CD-2 message format does not accommodate, shall be provided to the message formatter for future implementation. Examples of this type of data are the strobe amplitude information, strobe elevation angle information, second function scan to scan correlator information, increased range accuracy LSB information, increased azimuth accuracy (IACP data) LSB information, etc.

3.5.13.4.3 Output Formats.- Separate output formats for each port shall be provided, accommodating all of the possible aforementioned capabilities.

3.5.13.4.4 Future Configuration.- The ARSR-4 design shall not inhibit the configuration shown in Figure 3-5 below from operating. In the event the Mode S processor fails, the ARSR-4 shall reconfigure in the same manner specified in 3.5.18.6. Figure 3-5 does not imply any preferred physical block diagram and is only included to aid the contractor's understanding of the functional relationship required.
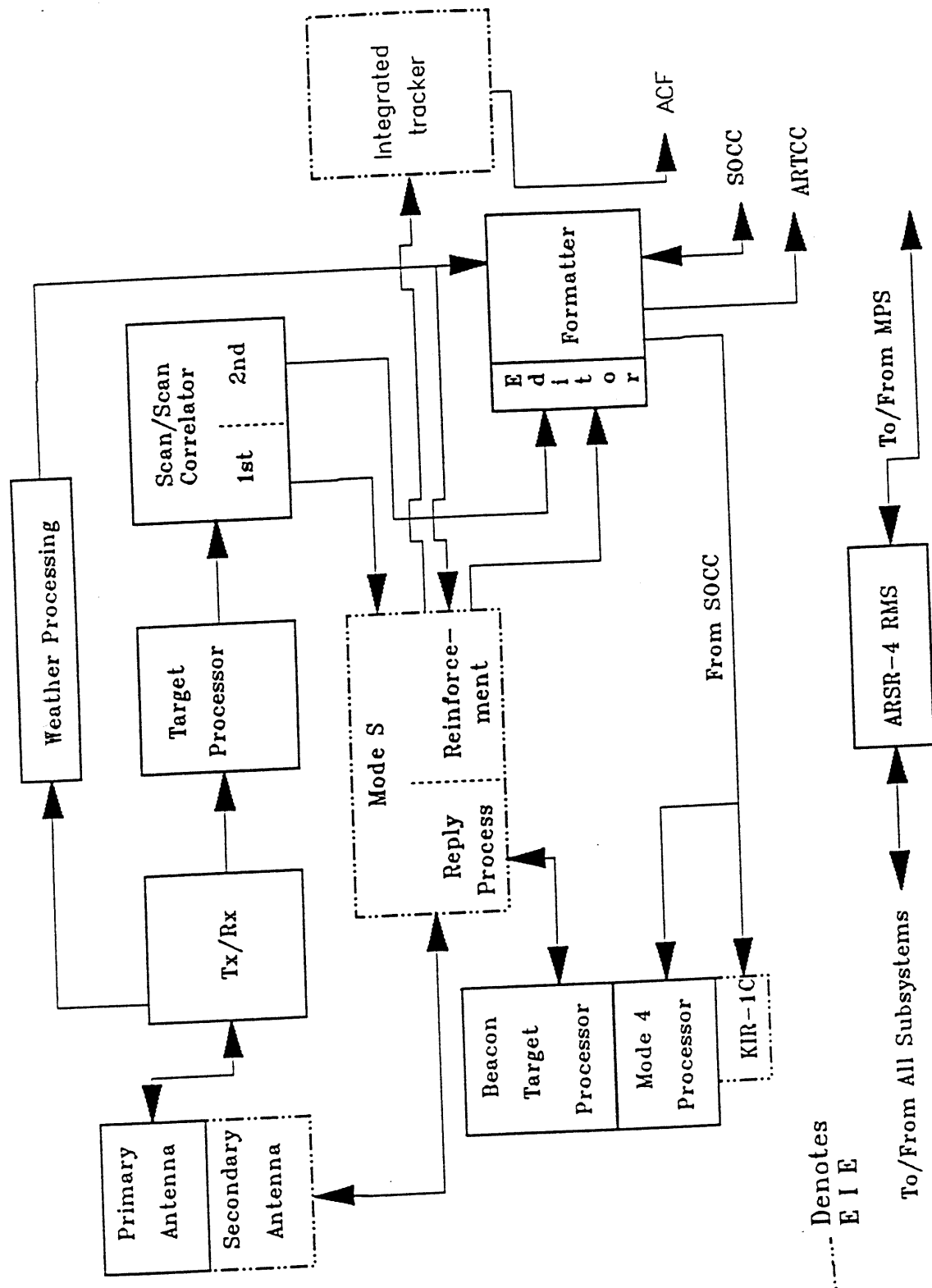
Figure 3-5, ARSR-4 WITH MODE S

3.5.13.5 Time of Year Clock.- The ARSR-4 shall include a real time system clock which provides the time of year. The clock shall usually display time of year in decimal digits. It shall display the day of the year, hours of the day (through 24 hours), minutes, and seconds. The clock shall reference a Universal Time Standard with an accuracy of +/-5.0 msec, and shall have the ability of sustaining that accuracy over a period of at least 180 days. Additionally, the Time of Year Clock shall have an external synchronization capability to drive the clock from an external time source or externally drive other clocks.

3.5.13.5.1 Time of Year Clock Buffered Outputs.- The clock shall provide buffered outputs at which the time code shall be available. The outputs shall consist of day, hour, minute, seconds, and seven bits of fractional seconds (LSB < 1/128 sec). Additionally, the clock shall have the capability of interfacing with the output of search target extraction and beacon target processing functions so that time tags can be placed on each outgoing message so that time of detection for each target can be established. The formatter shall have the capability to output target messages with or without time tags and shall also use the time tags to establish TIS.

3.5.14 Not used.-

3.5.15 Remote Monitoring Subsystem (RMS).- The ARSR-4 shall include a remote monitoring subsystem providing the capability of monitoring the operational status and key performance parameters of the ARSR-4 as well as adjusting performance in response to changes in the external environment or local equipment failures. Operational requirements for the total remote maintenance monitoring system (RMMS) and the local equipment RMS are given in NAS-MD-792. Functional requirements for the RMS are detailed in NAS-MD-793.

3.5.15.1 Monitor and Alarm.- The radar RMS shall continuously monitor all critical parameters to determine if the equipment is operating within specified limits. Parameter values shall be compared with known values or operational limits, and any deviation from the tolerance values shall be flagged as alarms. The RMS shall have the capability of distinguishing between two levels of alarms which are described in the following subparagraphs. The RMS shall generate a "return to normal" alarm when the previously reported alarm condition returns the system to specified operational limits. The RMS shall have the capability to disable and enable reporting of all alarms. An indication sent to the MPS of the alarm being disabled shall be provided.

3.5.15.1.1 Operational Failure Alarms.- These alarms indicate that a system performance failure has occurred. They require immediate notification to the monitoring facility. Performance failure includes degradation outside prescribed limits or complete equipment failure. Failure of redundant units shall be included in this category.

3.5.15.1.2 Pre-Alarms.- This category, also defined as "soft alarms", indicates that system performance has degraded below a certain point, predicting possible imminent failures. Pre-alarms include system performance nearing maximum limits and subsystem failures not in themselves causing a system performance failure.

3.5.15.2 Remote Control.- This capability shall allow facility restoration actions from a remote location. The equipment may be powered up or down, switched from main to standby, etc. The RMS shall interpret messages containing remote control information and additionally have the ability to attempt reset of equipment (on its own) before a failure is declared. The monitoring facility shall be notified of the reset attempts.

The RMS shall complete remote control commands within two seconds average and five seconds maximum (99th percentile) measured from the time the command is received by the RMS to the time the command execution is completed.

3.5.15.3 Performance Certification.- The radar RMS shall, on a continuous basis, monitor and store data pertaining to critical operating parameters. This data shall be kept current by updating as soon as any change occurs. At regular intervals the controlling site will automatically poll the facility RMS to determine the current status. Polling on demand shall also be available. In addition to passive monitoring of parametric data, dynamic performance tests shall be conducted to provide equipment condition and operating data. These dynamic tests shall be automatic with the capability of an operator override.

3.5.15.4 Diagnostics.- The RMS shall provide appropriate hardware, software, and control signals to adjust the operational equipment and perform diagnostic tests. These tests shall provide sufficient diagnostic and fault information to assist specialists, both locally and from a remote location, to locate failing or failed LRUs, and to meet the requirements of 3.4.4.4.

The RMS shall acknowledge the receipt of a valid diagnostic test command. The test diagnostic command acknowledgment shall be reported within two seconds average and five seconds maximum (99th percentile) measured from the time the diagnostic test command is received by the RMS until the time the diagnostic test acknowledgment is ready for transmission to the concentrator (awaiting poll).

The RMS shall collect and report diagnostic test results within 50 seconds average and four minutes maximum (99th percentile) measured from the time the diagnostic test is initiated until the diagnostic test report is ready for transmission to the concentrator (awaiting poll).

3.5.15.5 Remote Adjustments and Selection.- The RMS shall have the
capability of permitting adjustment of the equipment from a remote location.
Messages originating from the MPS will be passed through the
telecommunications network to the radar RMS.   Site adjustments shall be made
by means of a terminal, either the LDC terminal (3.5.16) or a portable
terminal* (EIE), connected to the RMS.   All parameters that are specified as
field adjustable or selectable shall be capable of being adjusted or selected
at a remote location as well as at the radar site.

> *   The portable terminal specified herein will be a computer terminal
> provided by the Government which will be used by a technician to
> interface with the ARSR-4 RMS.   Its interface requirements are
> specified in 3.5.15.7.

Any or all changes in operating parameters induced by the automatic controls
shall not cause ARSR-4 performance to degrade below the performance level
requirements stated herein.   All changes in operating parameters induced by
any manual controls shall be reported to the MPS for recording.

3.5.15.6 Not Used.-

3.5.15.7 Remote Maintenance Monitoring (RMM) Interfaces.- The external
interface standard shall be EIA-RS-232, 2400 bps or higher, selectable channel
data rate, and synchronous transmission.   The protocol standard shall be a
subset of ANSI X3.66 ADCCP, Synchronous Data Link Control (SDLC) frame (Normal
Response Mode with Primary or Secondary station) using a "Data Point Transfer
Message" embedded in the SDLC data field as defined in NAS-MD-790.

3.5.15.7.1 Interface Control Document (ICD).- External interfaces of
equipment shall be designed to meet all electrical interface requirements for
data exchange, timing, and data link control procedures for bit oriented data
link interchanges as specified in NAS-MD-790.   The standards specified therein
are applicable in their entirety to the interface between equipment RMS and
concentrator (EIE), and between RMS and MPS.   The interface between the RMS
and portable terminal shall be asynchronous and shall conform to EIA-RS-232.
Requirements for the portable terminal interface protocol standard shall be
submitted by the contractor and approved by the Government.

The RMS shall have a "lock-out" feature in which any remote control via RMMS
is disabled.   Additionally, the ARSR-4 RMS shall notify the MPS that the
control of the ARSR-4 is under local control by either a portable terminal or
the ARSR-4 LDC (3.5.16.2).

3.5.15.7.1.1 Portable Terminal Messages.- The RMS shall provide for the
transfer of messages from the uplink concentrator to the portable terminal or
from the portable terminal to the uplink concentrator.   The RMS shall be
capable of transferring messages of up to 4096 bytes to or from the portable
terminal in an average time of five seconds to a maximum time (99th
percentile) of eight seconds.

3.5.15.7.2 Interface Definition.- The contractor shall supply the following interface information to the Government.

	NAS-MD-790 Reference
Item	
	3.2
Link level address	3.2.2
Logical unit address and names	
Additional message function codes	3.3.1
over and above NAS-MD-790 requirements	
Data point identifications and names	3.3.2
(arranged by logical unit)	3.3.3.2
(1) Range and value identification	3.3.3.2
(2) Normal/abnormal status	3.7
System specific commands	3.7.8
Format of downloadable data	5.5.3
Maximum number of retries for link level recovery	

3.5.15.8 Radar Remote Monitoring Subsystem (RMS).- The radar RMS shall be furnished as an integral part of the basic radar. It shall be designed to operate continuously to ensure that ARSR-4 malfunctions are promptly detected so that proper corrective maintenance can be performed. Integration into the radar system shall be such that a failure of the RMS equipment shall not cause deterioration or loss of radar service. The RMS shall exert monitor and control functions on the radar equipment through a duplex communication network to a MPS at a remote controlling point. The RMS shall utilize an EIA-RS-232 port to communicate with the external communications network.

3.5.15.8.1 RMS Processor.- The RMS Processor used in the radar RMS shall have the speed and capability to perform the required tasks. An automatically switchable redundant RMS Processor shall be provided. The computer shall provide sufficient I/O channels, plus 10 percent unused spares, to interface with the following:

(a) All required radar test points and control functions (3.5.15.8.6).

(b) The LDC printer, keyboard, and display (3.5.16)

(c) The data extraction subsystem and tape recorder (3.5.25)

(d) The printer (3.5.16)

(e) The portable terminal (EIE)

(f) The site concentrator (EIE)

The software requirements of this specification shall apply to this processor. The RMS Processor shall incorporate EIA-RS-232 interface capability, ANSI X3.4 ASCII code compatibility, and IEEE-488 programmable instrumentation capability. Spare memory shall be provided by the contractor in accordance with 3.11.10.

A commercially available processor may be used for the RMS Processor provided all reliability/maintainability/availability requirements stated herein are achieved and it is proven to the Government as meeting those requirements.

An I/O port, compatible with the RMS Processor, shall be made available at the input and output of all major processing functions within the ARSR-4. Search radar target amplitude information shall be made available on all or any number of selected live or test targets.

3.5.15.8.2 On-line/Off-line Monitoring and Diagnostics.- The RMS shall continuously monitor the performance of all on-line ARSR-4 subsystems, and on a noninterferring basis with the processing of on-line data, perform sufficient tests to ascertain that the subsystems have not degraded. Any standby subsystem, when in an off-line status, shall have performance monitoring testing in the same manner as the on-line subsystems. When in maintenance status, performance monitoring of standby equipment shall be disabled and no alarms generated. The RMS shall include software instructions, resident in firmware, to exercise each and every digital and analog subsystem and its interfaces. The purpose of this firmware shall be to conduct analysis of the entire radar system performance in an off-line mode. The on-line diagnostic firmware shall isolate faults to the levels specified in 3.4.4.4. More detailed off-line diagnostics shall be provided as required to meet the system restoration time. The capability to select and initiate off-line diagnostics shall be field selectable, and the capability to print and display off-line diagnostic data on the LDC (3.5.16) or the portable terminal (EIE) shall be provided. Displayed results of diagnostics shall be easily understood without the need to refer to documentation. Provisions shall be incorporated to look at target processing at various stages in the video processing chain. These points shall be brought to test connectors and shall be capable of being accessed by external test equipment and the LDC (3.5.16).

3.5.15.8.3 Search Test Target Generator (STTG).- A STTG shall be included as part of the Radar RMS/BITE subsystem. It shall be under software control and be field adjustable except for the RTQC. The range, start azimuth, runlength, and number of targets shall be selectable. The STTG shall supply Radio Frequency (RF) and Intermediate Frequency (IF) signals derived from receiver Reference Frequency sources, and shall not require retuning if the receiver frequency is changed. The STTG shall not interfere with the operation of the receiver. Isolation of the STTG shall be such that it shall not degrade the operation of the receiver regardless of the failure mode of the STTG. The RF level introduced by the STTG at any point in the receiver channel when the test target pulse is switched off shall be at least 70 dB below the test target amplitude setting, and below system noise. The STTG shall be used to provide test targets for diagnostics, testing system capacity, and testing equipment performance.

3.5.15.8.3.1 Target Types.- The following modes of target generation shall be included in the STTG design.

    (a)   Target for RTQC (digital for on-line operation)

    (b)   Strobe target (video for maintenance operation)

    (c)   Ring targets (RF for maintenance operation)

    (d)   Weather targets (IF for maintenance operation)

    (e)   RF and IF targets (for performance monitoring)

3.5.15.8.3.2 Real Time Quality Control (RTQC) Target.- A test target shall be generated that is adjustable in range, azimuth, and height as follows.

    (a)   Range   0 - 1.5 nm

    (b)   Azimuth of first hit   359 - 1 degree

    (c)   Azimuth extent   60 - 70 ACPs

    (d)   Height   10,000 - 40,000 feet

This target shall be generated once per scan and shall be fixed in range, azimuth, and height. Normal target input to the point where these targets are inserted shall be inhibited for the test target range cell and over the test target azimuth extent. The test target information shall be processed in the same manner as any other search target information except that runlength rejection shall be bypassed, and the resultant system output message shall have the test target flag set. Although this test target is generated primarily for use in the central processor at the ARTCC and SOCC, it shall also be used in monitoring the radar digital processor to detect local malfunctions in the processing chain.

3.5.15.8.3.3 <u>Strobe and Ring Targets</u>.- A total possible population of evenly distributed targets, every 10 nm in range by 32 targets in azimuth (800 total targets), shall be capable of being generated by the STTG when the radar is in an off-line maintenance mode. Field adjustment of the number of targets in range and azimuth shall be possible in order to generate strobe or ring targets in numbers up to 50 percent greater than specified system capacity. The location of strobe and ring targets shall be capable of being positioned over the full range and azimuth of the ARSR-4. All targets in the selected mode shall be capable of being modulated in phase to appropriately excite the clutter processor being used, therefore, simulating fixed (zero velocity) targets or moving targets (variable to an optimum velocity). The targets shall be field adjustable in width from 1 ACP to 40 ACPs. The selected population of targets shall be field adjustable in range or azimuth every scan to simulate speeds of 0, 100, or 500 knots. Simulation of speed by change in azimuth shall assume a range of 100 nm. Targets at other ranges shall be given the same angular velocity as those at 100 nm.

3.5.15.8.3.4 <u>Weather Targets</u>.- The STTG shall generate two calibrated CW IF weather targets independently field adjustable in amplitude in 1 dB steps from noise to 3 dB below the level required to saturate the A/D with no STC. The calibrated amplitude shall be the amplitude sensed for a weather storm at 100 nm with no STC. Amplitude shall vary in range only as a function of STC. If the normal transmit waveform is made up of subpulses at different RF frequencies and the weather processor only uses one of the subpulses at a given range as part of the weather detection process, then the single IF frequency (corresponding to one of the RF subpulses) at which the weather target shall be injected shall be field selectable. The range extent of each simulated weather target shall be field adjustable from 5 to 245 nm in 1 nm steps. The simulated weather targets shall be field adjustable in azimuth width from 1.4 degrees to 360 degrees in 1.4 degree increments. The center of each simulated weather target shall be capable of being positioned by field adjustment anywhere in the radar coverage in increments of 1.4 degrees and 1 nm. The mean doppler of the weather targets shall be field adjustable from -50 to +50 knots in 1 knot increments. Weather targets shall only be injected when the weather channel is in the Maintenance Mode. Weather targets shall normally be injected into only the weather channel. For maintenance purposes, a means shall be provided at the site to inject the weather targets into one of the target receive channels in addition to weather channel.

3.5.15.8.3.5 RF and IF Performance Monitoring Targets.- Suitable targets shall be generated on a continual basis, in addition to the RTQC targets, to provide a constant monitor of system performance. They shall be RF, IF, or video, as needed, and shall normally be injected during the radar dead time so as not to interfere with the RTQC target and normal operation. These targets shall be used for diagnostics, as well as performance monitoring, and shall be field adjustable. The RF output of the STTG shall be capable of being varied independently in phase and in amplitude over the dynamic range of the receiver. The test targets shall simulate velocities from zero to +/-3,000 knots, adjustable in one knot increments. Amplitude adjustments shall be in 1 dB steps within the dynamic range of the Analog to Digital (A/D) converters and shall not cause phase changes. Phase adjustments shall not cause a change in the amplitude of the test targets. A moving target or targets capable of being positioned anywhere within the coverage area, continuously adjustable in velocity from 0 to 3,000 knots and height from 0 to 100,000 ft shall be generated. These targets shall be usable for checking the scan to scan correlation. These targets shall be injected into each elevation beam receive line for use in checking and aligning the analog and digital height function of the radar. Equal and unequal signal levels shall be used to simulate target returns above, below, and in the center of the beam cross-overs. The field adjustable selection of target injection shall be made by individual beam and beam pairs. Performance parameters such as receiver sensitivity and clutter processor performance [Subclutter Visibility (SCV) and Improvement Factor] shall be available on request from the remote and local RMM control. The performance monitor test targets shall normally be set at a level and extent necessary to provide automatic and on-request certification parameters as listed in 3.5.15.8.6. If any certification parameter falls outside given tolerances, an alarm shall be verified within 12 seconds of its occurrence. These targets shall also be used to detect possible faults in the entire receiving/processing subsystem from the RF front end to modem drivers. Indication (display and print) of the fault location (LRU or LRUs) shall be available to the RMS processor and to both the local and remote control points.

3.5.15.8.3.6 Constant False Alarm Rate (CFAR) Test.- If CFAR circuitry is utilized in the ARSR-4, then suitable test targets shall be incorporated to test that CFAR operation.

3.5.15.8.4 Beacon Test Target Generator.- Beacon test targets shall be generated by a separate test target generator or may be incorporated in the STTG, at the contractor's option. The following types of targets shall be generated.

3.5.15.8.4.1 Beacon RTQC Target.- A Beacon RTQC target shall be inserted
with the reply video pulse train from the site beacon interrogator at the
beacon input to the ARSR-4. The beacon RTQC target shall be positioned in
dead time at a range of 1 nm and an azimuth of 180 degrees. The beacon RTQC
target shall have an azimuth extent equal to 64 ACPs and a field selectable
reply mode of 3/A, 2, or C; all 1s; or all 0s. As with the search RTQC
target, the beacon RTQC target is primarily used at the ARTCC or SOCC. It
shall bypass any runlength discrimination and have the test target flag set.
Beacon video shall be inhibited for test target range cells and over the
azimuth extent of the beacon RTQC target.

3.5.15.8.4.2 Beacon Operational Test Targets.- The following types of test
targets, under control of the RMS, shall be inserted into the BTP. The
operational BTP tests shall operate continuously when the BTP is in the normal
operating mode. The insertion point and video parameters shall be field
adjustable. The test target generator output for these operational test
functions shall not contain the test indicator signal, but shall appear as
normal, live target data. External beacon video shall be inhibited for the
minimum time necessary to prevent interference or garbling of the test
signals. The test signals shall include the following conditions at a
minimum:

(a)   Framing pulses with acceptable and unacceptable pulse spacings.

(b)   Code pulses that are correctly and incorrectly located with
       respect to both normal and wide framing pulses.

(c)   Reply codes and range separations which verify the correct
       elimination of phantom and C2-SPI false brackets; the proper
       detection of interleaved, overlapped, and special military
       replies; and the correct correlation and range and azimuth
       resolution of the replies by the target detection algorithm.

(d)   Simulated Mode 2, 3/A, and C targets which verify the correct
       operation of the target detection, code validation, code
       transformation target position bias correction, military emergency
       replies processing, SPI AND X-bit validation operation, processing
       and reporting of beacon emergency codes, and runlength processing
       and encoding functions.

The operational test targets shall be generated as close to the adapted BTP maximum processing range as is possible and, in contrast with the RTQC test targets, shall be for internal BTP status monitoring only. All test target data shall be capable of being displayed and printed through the RMS on a portable terminal and on the LDC; but shall not be transmitted to the modems. The operational test shall detect any loss of data as the result of the overflow or failure of any register, buffer, or complete memory subsystem within the BTP. Normal adjustments of the BTP's parameters such as beacon offset, maximum range, runlength discrimination, and other similar parameters shall not impair the effectiveness or accuracy of the BTP operational test. A complete operational test cycle shall be completed and the results updated at least once every antenna scan.

The BTP and Mode 4 equipment shall generate a Mode 4 Test Target in less than 0.5 seconds after receipt of a Mode 4 Test Target message.

3.5.15.8.4.3 BTP Diagnostic Test.- The BTP's diagnostic test shall be able to be initiated only when the subsystem is off-line. The BTP diagnostic test shall be field selectable. The diagnostic test shall include the following as a minimum:

(a) A check of all microprocessor operational memory to insure that the correct data is in each memory location.

(b) A thorough, rigorous check of all random-access and scratch-pad memories to ascertain their operating conditions.

(c) Verification of the correct operation of each computing unit in the microprocessor/software module.

(d) Verification of the ability of the processor to process internal data in the absence of external stimuli.

(e) Verification of the correct operation of the five alarm detection features in the BTP [3.5.9.1.16(c)].

(f) Verification of the correct operation of the beacon strobe processing and output message generation functions.

(g) Verification of correct Mode 4 operation using a closed-loop test with Mode 4 equipment.

The test signals necessary for tests (e) through (g) above shall be generated, inserted, and able to be displayed in the same manner as the BTP operational test target signals.

3.5.15.8.5 Data Count Monitor.- A six digit decimal counter shall be incorporated in the RMS for the purpose of measuring the system data count. Inputs to the counter shall be field selectable videos from the receiver and processor. The counting time of the data count monitor counter shall be field selectable in both time and scan count. In time, the counting shall be selectable from one, five, and ten seconds. In scan count, the counting shall be selectable from one to ten scans. Video inputs shall include as a minimum:

    (a)   Quantized beacon video

    (b)   In-process beacon video

    (c)   Processed beacon video

    (d)   Bracket video

    (e)   Video points at each step in the search target processing chain

    (f)   Weather threshold video

3.5.15.8.6 Firmware Requirements.- Firmware requirements for the RMS shall be as follows:

    (a)   Firmware shall include modules to support spectrum analysis [a Discrete Fourier Transform (DFT) utilizing samples from the radar's nine (9) interpulse period sequence] of received targets from stationary objects with the antenna stopped. The DFT shall consist of a minimum of 37 discrete filters with each filter processing a minimum of 54 pulses. The object shall be to determine the stability of the processing subsystem by comparing the amplitude and extent of the sidelobes generated away from the center zero frequency filter. The interface of the processor shall be with A/D converter outputs specifically provided for this purpose. The LDC (3.5.16), through the RMS and displayable through the RMS, shall display the results of the analysis in the form of calibrated spectral lines with the ordinate in dB and the abscissa in positive and negative frequencies from zero frequency. It shall be possible to expand the ordinate and abscissa.

    (b)   Diagnostic executive.- A program shall be provided in the ARSR-4 that integrates all the diagnostic modules into a cohesive software system. It shall display on the LDC and portable terminal a menu of the diagnostic routines available and shall, by keyboard entry, direct the execution of any program in the menu. Results of the diagnostics shall be interpreted and displayed in plain language. The results of the diagnostic test shall be available at the RMS within the time specified in 3.5.15.4.

(c)   Performance analysis.- A menu of all the performance related programs listed below shall be provided. The capability to select and initiate all of the performance related programs listed below and display of the resultant data shall be provided as requested at either the RMS and MPS. Display of the results of each test shall be in graphical or tabular form and shall be readily interpretable. In all cases, actual values shall be provided except as noted or appropriate. All alarm functions shall be provided with thresholds adjustable for both soft and hard alarms. Actual values shall be obtainable on demand through the RMMS to the MPS and at the LDC and portable terminal.

Real time monitoring of video/digital processing.
Key performance parameters, to be selected by the
Government.
Programmable alarm limits.
Number and percentage of reinforced reports processed.
Test target range, azimuth, amplitude, velocity, and Pd.
Radar system status.
Weather Processing Status.
A list of the field and site adjustable/selectable parameter
settings.
Number of targets out of the BTP
Number of target reports out of the search target extractor.
Number of target reports out of the scan to scan correlation
for each of its two functions.
Number of target reports out of the editor.
System Performance listed below as a minimum.

Power supply voltages
Azimuth accuracy
Transmitter power (average and peak)
Receiver sensitivity (Minimum Discernible Signal(MDS))
Memory checks
Digital Signal Processor filter performance (if
processing by filters)
Digital Signal Processor performance (if processing by
range segments)
Scan to scan correlation performance
Editor performance
Formatter performance
Timing checks
Weather Processor performance
Transmitter pulsewidth
Transmitter pulse spectrum (if appropriate)
Weather Station performance
VSWR

                    BTP performance (as a minimum)
                    Mode 4 performance
                    Beacon/Search reinforcement function
                    Alarms listed below as appropriate
                    Transmitter Overvoltage
                    Transmitter Undervoltage
                    Transmitter Overcurrent
                    Transmitter Undercurrent
                    Modulator Overload
                    Driver Overload
                    Final Power Amplifier Overtemperatures
                    Airflow Failure
                    Waveguide Pressurization Failure (as appropriate)
                    Power Supply Failure
                    Main Power Overvoltage
                    Cabinet Overtemperature
                    Pedestal Oil Level
                    Transmitter Output Power
                    Azimuth Alarm
                    Test Target Alarm
                    Target Overload
                    Antenna Drive Motor
                    APG and ARP Alarms
                    Waveguide Arc Detection (as appropriate)
                    BTP Performance Alarms (Including Mode 4 alarms)
                    BTP Range Alarm
                    BTP Azimuth Alarm
                    BTP Output Alarm
                    BTP Overflow Alarm
                    Beacon Mode Alarm
                    System Performance Alarms
                    Beacon/search Reinforcement Alarm
                    Weather Processor Failure Alarm

        System Status Read-Backs listed below as a minimum and available

        Transmitter on/off
        Redundancy availability
        Beacon Offset Selection
        Beacon Runlength Discrimination Selection
        Weather Level 2-3-4-5-6 Selected
        Antenna/Beam Rotation (on/off)
        Ka or other refraction profile as appropriate
        Beams in use
        Field/Site Selectable Parameter Setting
        Field/Site Adjustable Parameter Setting

    Off-Line Diagnostic Results (Identification of replaceable LRU failure
    as specified in 3.4.4.4)

(d) The STTG Control.- Firmware shall generate the signals required to control the STTG. The status of the STTG including the target range, azimuth pattern, amplitude, filter,and ground speed shall be also be displayed.

(e) The Beacon Test Target Generator Control.- Firmware shall generate the signals required to control the Beacon Test Target Generator. The status of the Beacon Test Target Generator including the range, azimuth, codes, framing pulses modes, range separation and ground speed shall also be displayed.

3.5.15.8.7 Built In Test Equipment (BITE).- The contractor shall determine the test equipment necessary for performance monitoring and/or diagnostics, provide all such test equipment (with equipment instruction books in accordance with the SOW) and suitable/necessary mounting, interconnection cabling, and sensors to implement the RMS as previously described herein. All BITE used in the RMS shall be designed in such a manner as to allow calibration of that equipment on a periodic basis that can be traceable to the National Bureau of Standards. The test equipment shall be designed in such a manner as to hold its specified accuracy for at least 180 days before requiring recalibration. The ARSR-4 and its test equipment shall be designed in such a manner as to enable the test equipment calibration while the ARSR-4 is on-line.

The contractor shall provide all test equipment racks, sensors, readouts, wires, and/or cable interconnections or accessories necessary for operation of test equipment associated with the RMS. The contractor shall provide any special calibration equipment and instructions, as stated above, necessary to calibrate all test equipment.

3.5.15.8.8 Report Mode.- Report generation and processing shall be provided and structured in accordance with message formats and interactive procedures specified in NAS-MD-790, with the following exceptions: 1) Condition Status Codes shall be transmitted with every data point sent in a Site Data Report, and 2) The high and low threshold values for both hard and soft alarms must have their own data point identification numbers. The message report format shall be used for interaction for the ARSR-4 command/control using the RMS on-site portable terminal (EIE) and the LDC. Report requests can be addressed to either the MPS or directly to the ARSR-4. Full ARSR-4 control shall be available, through site selection, at the LDC (3.5.16) and at the RMS on-site portable terminal interface port through the RMS.

3.5.15.8.8.1 Alarm Reporting.- Alarm processing and reporting shall pre-empt and interrupt all other report processing modes. A verified alarm report shall be generated and transmitted to the MPS on the next poll in accordance with NAS-MD-790. A pre-alarm shall be reported to the RMS in less than 12 seconds after its verification. Verified alarm reports shall be processed and transmitted to the MPS on a first-in, first-out basis. Alarm reports shall be retained in storage until they are transmitted to, and acknowledged by, the MPS.

3.5.15.8.8.1.1 <u>Automatic Fault Alarm Reset</u>.- The ARSR-4 shall contain an automatic RMS alarm reset function to assist meeting the requirements of 3.4.4.4 with respect to true and false alarms. This function shall reset consecutive fault alarms up to 8 times (site adjustable between 1 and 8) or that quantity which equals 12 seconds, whichever is less, before verifying the alarm to the RMS. Additionally, the automatic fault reset function shall count random fault resets for each alarm condition. When this count exceeds 8 for any alarm condition and alarm has not been reported to the RMS, a soft alarm shall be reported through the RMS. When this condition exists, the automatic fault reset for the particular alarm condition involved shall be automatically disabled. The fault count shall be made over a sliding window period which is adjustable between one hour and 24 hours in 30 minute increments. The automatic fault reset function shall remain disabled for that alarm condition which caused the disabling, until intervention through the RMMS clears the count.

3.5.15.8.8.2 <u>Remote Monitor Subsystem (RMS) Status Reporting</u>.- Status report requirements shall include various types of requests which can be initiated manually by maintenance personnel. This initiation shall be done at the local site through the RMS or through the MPS. Initiation shall also be done automatically through the MPS. Both the manual or automatic initiation shall be done for either a specific status of a parameter within a group, or a number of groups of monitored functional parameter values; or for a complete status report consisting of all groups in 3.5.15.8.6(c).

The RMS shall report any change in current status within two seconds average, 10 maximum (99th percentile) measured from the time the status change occurs to the time the status change message is ready for transmission to the concentrator (awaiting poll).

3.5.15.8.9 <u>Remote Maintenance Monitoring (RMM) Diagnostics</u>.- The RMS, built into the ARSR-4, shall be designed to be fail-safe. Any failure in the RMS shall not disrupt any radar functions or cause operation outside normal certified parameters. The RMS shall contain built-in diagnostic tests, in firmware, designed to alarm if a malfunction is detected and to locate the malfunction (3.4.4.4). RMS failure alarms and diagnostics shall be made available to the MPS via RMMS, at the portable terminal port, and at the LDC. Isolations of failures shall follow the conditions as specified in 3.5.15.8.2. MTBCF of the RMS shall be no less than four times that of the ARSR-4, and MTTRS shall be no greater than that of the ARSR-4.

3.5.16 Local Display Console (LDC).-

3.5.16.1 Plan Position Indicator (PPI)/Random Access PPI (RAPPI).- The

ARSR- 4 shall include a LDC which shall serve as the primary interface for the operators, and maintenance functions. Operations of the ARSR-4 shall be able to be initiated or controlled from the front panel of the LDC. The LDC shall contain a combination PPI/RAPPI to display video data or a combination of video data (i.e., PPI and RAPPI data at the same time with contrast capability to differentiate one from another) from the ARSR-4 equipment and from positions before and after major processing functions within the ARSR-4 processing chain. The timing of all videos displayable on the LDC shall have target data located and aligned at the same azimuth and range.

3.5.16.2 Console Requirements.- The LDC shall be used as a maintenance

console during normal operation and as operator/controller console during emergency operation. The LDC shall be capable of providing simultaneous display of radar videos (analog and digital videos displayed at the same time) mixed with beacon video, range marks, and cursor. Controls and displays shall be provided to permit measurement of range and azimuth of any displayed target. The capability to pair any two operator-selected RAPPI target symbols shall be provided for up to six selected target pairs. A pairing line connecting the targets and an associated data block shall be displayed for each set of paired targets. The data block shall provide range, bearing, and height data for the second target relative to the first. Controls shall also be provided to select targets on the PPI/RAPPI (live or test targets) whose height information will be displayed on the tabular display. Additionally, beacon target data [Modes 2, 3/A, 4 (friend evaluation results), and C code information] shall be displayed on the LDC on either the tabular or digital displays via target selection with the cursor. The displayed alphanumeric target report data shall be organized in a vertical format. The capability to selectively display the report data in hexadecimal format as it is received from the data processor shall also be provided. The capability for the operator to relocate the position of the PPI/RAPPI data block from the tabular display area, to any desired location within the PPI/RAPPI display area shall be provided. A switch in the NSA-approved security container (Mosler or Hamilton) shall be manually enabled before the Mode 4 evaluation bits, D1 and D2, will be displayed on the LDC. The LDC shall be capable of displaying digital plot video with appropriate symbology to display all types of messages specified in 3.5.13. The 'up to three Mode 4 inhibit sectors' specified in paragraph 3.5.20.3.1.3.2 (b) shall be selectively displayed as a pair of full screen vectors for each sector emanating from the radar origin. A vector pair with shading emanating from the radar origin, bisected by the reported strobe symbol bearing, shall be displayed for each displayed strobe report. The bearing extent of the vector pair shall be derived from the strobe report runlength. The LDC shall be capable of displaying analog, digital and D/A video data (3.5.15.8.2) from various stages of the data processing chain as determined by the contractor and approved by the Government. A strobe video shall be made available at the demarcation point and at the LDC.

All ARSR-4 systems shall have a capability to drive multiple displays to fulfill some operational requirements. The contractor shall design the ARSR-4 to facilitate two display configurations which meet the following conditions:

(a) In the first configuration, a demarcation point using general purpose type connectors shall be provided in such a manner as to allow three additional displays to be connected in parallel to the master LDC. Each of the three additional displays shall have the capability to drive an additional four displays. Capability to remote these additional displays up to 300 feet away from the ARSR-4 equipment room shall be provided. Analog and digital search, beacon, and strobe videos; and azimuth data shall be made available at that demarcation point for each of the three additional displays.

(b) In the second configuration, the LDC shall be designed in such a manner so to enable displays to be connected in series to each other. Each LDC shall have buffered output ports, to provide isolation, and connectors available to slave additional LDCs in such a manner as to allow full ARSR-4 control on the first LDC, which shall serve as a master LDC, and the other LDCs shall be used for display purposes only.

The capability of having both configurations implemented at the same time shall be provided. In both of the aforementioned LDC configurations, Mode 4 request, enabling, and display signals shall be available at any and all LDCs.

A minimum of two displays shall be provided in the LDC. One of the displays shall be a tabular display and shall provide temporary (volatile) display of digital data; including selected output messages, test results, target beacon code information, and search height information; in decimal form. The diameter of the tabular display shall be at least 9 inches diagonally. The LDC shall have a keyboard terminal with a data display (in addition to the video display, but can be a part of the tabular display) which shall be used by maintenance and operations personnel for controlling and monitoring the ARSR-4 at the site via the RMS. It shall have the equivalent capabilities, as a minimum, as the portable terminal as described herein. The second display shall be a PPI/RAPPI display and shall be at least 16 inches in diameter. If less than four pulses per beamwidth and/or less than one microsecond pulsewidth is used, a stretched azimuth and range video pulse shall be provided for the analog display. All the displays (PPI/RAPPI, tabular, data displays) shall be completely self contained in one package and shall be mounted on a low profile mobile cart as part of that package.

The LDC shall have the capability of providing operator control of the ARSR-4 from the operator's LDC position. All ARSR-4 controls available through the RMMS shall be made available at the LDC, which could interface with the ARSR-4 RMS in the same manner as the RMMS portable terminal. This LDC control device shall, as a minimum, provide the same features as the RMMS portable terminal (NAS-MD-792 and NAS-MD-793).

A printer shall be included to provide a permanent record of the displayed digital data. The LDC's display and maintenance features shall be considered as off-line or nonoperational functions of the ARSR-4, except during emergency on-site operation in which case the display is an on-line operational function. However, the operational control features of the LDC shall be considered to be a part of the on-line, operational ARSR-4 equipment.

3.5.16.3 Range Selection.- Variable sweep range covering the scale factors from 25 nm per Cathode Ray Tube (CRT) radius to 256 nm per radius, inclusive, in steps not to exceed 1/128 of a CRT diameter shall be provided. The range scale shall be indicated on the CRT in one nm increments.

3.5.16.3.1 Range Selection Offsetting.- The display off-center control shall provide for repositioning any X and Y coordinate between 5 and 250 nm to the center of the display. A range expansion control shall be provided to change the radius of the circular area displayed around the repositioned center from 5 to 30 miles. The expanded circular area shall extend from the repositioned center to the display edge.

3.5.16.4 Off-Centering.- Two selectable modes shall be provided for the display sweep origin: (1) Centered on the CRT axis and (2) offset to the CRT axis. In the offset mode, the sweep origin shall be capable of being offset in X and Y position at least one radius at the maximum sweep range. In addition, the sweep origin shall be capable of being offset in X and Y position at least four radii on the 25 nm sweep range.

3.5.16.5 Electronic Cursor.- An electronic cursor shall be provided, appearing as a line from the cursor origin to the edge of the CRT. The sweep trace curvature shall not exceed plus/minus 2 percent of usable CRT diameter with the sweep origin centered. For the purpose of this requirement, the curvature shall be considered the maximum deviation of the trace from a straight line. The cursor shall be suitable for making azimuth or bearing measurements on the CRT. The azimuth or bearing measurement and range measurement indications shall be presented on the CRT in alphanumeric form in increments no greater than 0.1 degree and 0.1 nm. The cursor intensity shall be adjustable and the following modes of cursor selection shall be provided:

(a) Cursor Off - The cursor shall not be operational in this mode.

(b) Cursor Centered - The cursor origin shall be coincident with the display Sweep Origin. For the purpose of measuring this parameter, a tolerance of +/-0.075 inch is applied to coincidence.

(c) Offset (Wandering) Cursor - The cursor origin shall be capable of being offset to any X and Y position on the CRT.

3.5.16.6 Range Strobe.- A range strobe, appearing as a unique symbol, shall be provided in all active cursor modes. It shall be possible to move the range strobe to any incremental position on the electronic cursor line, where the increments shall not exceed 1/512 of the CRT diameter. The range strobe shall be suitable for range measurements on the CRT with indication of measurement appearing on the CRT in increments not to exceed 0.1 nm. The bearing and range position of the range strobe shall be included as part of the PPI/RAPPI data block and it shall also be possible to tag the range strobe with its positional information. The range strobe shall be suitable for identification of targets or test pulses for which height is requested.

3.5.16.7 Range Marks.- Selectable range mark intervals of 5, 10, 20 and 50 nm shall be provided. Intensification of every fifth mark shall be provided.

3.5.16.8 Video Inputs.- The display shall be capable of accepting and simultaneous displaying all ARSR-4 video outputs in addition to the range marks and range strobe. Each video, including the range marks and range strobe, shall have independent gain (intensity) controls, ON-OFF switching, and ON-OFF status lights. An adjustable PPI persistence control for display of PPI videos shall be provided with adjustment for up to one scan.

3.5.16.9 Writing Shelf.- A writing shelf, extending the full width of the LDC, shall be provided on the front of the LDC. It shall provide a suitable working surface for an operator using a grease pencil in a darkened room. The shelf shall have built-in illumination with a separate dimmer control with power furnished by the basic display.

3.5.16.10 Compass Rose.- An illuminated compass rose (ring), graduated in one degree divisions and numbered at ten degree separations, shall be provided. The displayed compass rose shall be extinguished whenever the PPI/RAPPI origin is offset.

3.5.16.11 Implosion Shield.- A 1/4-inch thick plastic plate covering the face of the CRT shall be provided to serve as an implosion shield and a marking surface for grease pencils. This plate shall be easily removable from the CRT Assembly for cleaning and replacement.

3.5.16.12 Physical Design.- The LDC shall be designed so that all displays and indicators can be viewed and controls comfortably reached by an operator seated in front of the console.

3.5.16.13 Readout Inhibit.- It shall be possible to blank all displayed screen information except for the PPI/RAPPI presentation.

3.5.16.14 Antenna Position Indicator.- A real time antenna position indicator shall be displayed about the PPI/RAPPI circumference.

<u>3.5.16.15 RAPPI Symbols</u>.- Any combination of the symbology specified in the following shall be able to be displayed alone or together, limited only by the capacity of the output data circuits and the operational ARSR-4 equipment. Except for the displaying of the emergency code which shall always be enabled, each symbol shall be selected for display by individual front panel control. However, in the instance of the five weather contour symbols, it is permissible to use more than one control to select the symbols to be displayed, providing the individual control over each symbol is still achieved. When a symbol generation conflict occurs, because of the enabling of multiple symbol types and because of the presentation for display of a message which qualifies for more than one of those symbols, the display priority shall follow the order given in the following:

(a)   Emergency beacon (▧) - This symbol shall be displayed whenever a validated emergency beacon report is presented to the RAPPI.

(b)   AIMS (✳) - This symbol shall be displayed for any search, beacon or AIMS-only report in which the AIMS present bit and at least one AIMS code bit is set. The friend evaluation results shall be displayed on the LDC in a manner determined by the contractor. (e.g., displaying the evaluation results on the tabular display.)

(c)   Beacon bomarc (▨) - This symbol shall be displayed for any beacon report with a validated Mode 2 "X" bit, Mode 3/A "X" bit, or both. It shall also be possible to have this symbol displayed for beacon targets which meet other display symbol criteria.

(d)   Search-reinforced beacon (⊠) - This symbol shall be displayed for any beacon report which has its search radar-reinforced bit set.

(e)   Mode 3/A beacon (⊞) - This symbol shall be displayed for any beacon report with a validated Mode 3/A code.

(f)   Mode 2 beacon (⊟) - This symbol shall be displayed for any beacon report with a validated Mode 2 code.

(g)   Mode C beacon (⊟) - This symbol shall be displayed for any beacon report with a validated Mode C code.

(h)   Any beacon (▢) - This symbol shall displayed for any beacon target.

(i)   Search (✕) - This symbol shall be displayed for any search target report, including the search RTQC target.

(j)   Low intensity weather (—) - This symbol shall be displayed twice at the azimuth contained in each low intensity weather message, once at the start range and once at the stop range.

(k)   Medium Intensity ($\overline{\mathsf{I}}$) - This symbol shall be displayed twice at the azimuth contained in each medium intensity weather message, once at the start range and once at the stop range.

(1)   High intensity weather ($\mid$) - This symbol shall be displayed twice at the azimuth contained in each high intensity weather message, once at the start range and once at the stop range.

(m)   Strobe ( ) - This symbol shall be displayed for both beacon and search strobe reports.

(n)   Search with 3D height( ) - This symbol shall be displayed for a search target with a valid 3-D height.

(o)   Search reinforced beacon with 3D height( ) - This symbol shall be displayed for a search/beacon reinforced target with a valid 3-D height.

(p)   Military map ( ) - This symbol shall be displayed twice at the azimuth contained in each military map report, once at the start range and once at the stop range.

(q)   All targets (•) - This symbol shall consist of a distinctly visible dot and, when enabled, shall be displayed for any target or message which could be represented by one or more of the other symbols, providing that the other symbol or symbols are not enabled.

All symbols, except for the target dot, shall be approximately equal in height and width. These dimensions shall be at least 0.125 inches (3.2 mm), but not greater than 0.30 inches (7.6 mm). The target dot shall not be larger than 0.05 inches (1.3 mm). The RAPPI symbol size shall be independent of the RAPPI expansion.

The RAPPI shall be capable of displaying 5 weather symbols corresponding to NWS weather levels 2 through 6 to be proposed by the contractor and approved by the Government. These symbols shall replace the symbols in (j), (k), and (1) above when the expanded weather reporting capability is implemented.

3.5.16.16 RAPPI Refresh.- A display refresh capability shall be included with the RAPPI. The area to be refreshed shall be defined by a single sector, the start and stop range and azimuth values of which shall be able to be set anywhere in the RAPPI's coverage with a resolution of 0.7 degree and 0.5 nm or better. The refresh sector shall be established and the refresh function controlled from the front panel. When enabled, all of the symbols which are presented for display and which are within the sector shall be refreshed for a selectable period of one to ten scans in one scan increments. Targets which are more than one scan old shall be displayed at a brightness which may be reduced from that of all other RAPPI symbols, as controlled by a simple internal adjustment. The decay of the earliest symbol when the eleventh, if the ten refresh scan is selected, shall not distort the other symbols displayed. At least 100 targets (current and history) shall be able to be refreshed. If more than the designed number of targets are presented to the refresh circuitry, a suitable notation to that effect shall be conspicuously displayed on the front panel. The refresh shall be accomplished at such a rate as to not cause discernible flicker, regardless of the number of targets refreshed. The refreshed symbols shall be cleared by disabling the refresh function.

3.5.16.17 Printer.- The LDC shall contain a printer capable of providing a permanent record of the entire contents of the tabular display. The printed format shall conform as much as possible to that of the tabular display. The printed output shall include the time-of-year clock data at the top of the data block. It shall be possible to print one or both of the target messages available on the tabular display. The printer format shall be developed by the contractor and approved by the Government before equipment production is begun.

The printed copy shall be legible and remain legible for at least 10 years. The printer shall meet the requirements of paragraph 5.2.6.3 of MIL-STD-1472. Provisions for automatic printing as the contents of the tabular display are updated, automatic printing of either or both of the RTQC targets or the common format status message, and manual initiation of the print function shall be included. Operation of the printer shall be by front panel control. The most recent data shall be readable without manually advancing the printer. The printer shall be capable of printing at least 50 common output beacon messages per minute. The tabular and data displayed information shall be in commonly readable format (alphanumeric, decimal form).

3.5.16.18 Data Entry Devices.- The LDC shall include on its front panel all
of the controls and devices required to provide the routine operational and
maintenance control (3.5.16.2) of the ARSR-4. The contractor, using the human
engineering practices prescribed in 3.8.1.8 herein, shall design the front
panel of the LDC and its data entry devices for clear and logical
interpretation and operation. Data entry devices in this context include
potentiometers, switches, trackballs, joysticks, pushbuttons, and keyboards.
In the event that a keyboard is utilized to control a function such as printer
"on-continuous," RAPPI symbol display selection, or weather threshold
calibration, appropriate readback shall be provided to inform the operator of
the condition of the function. This readback, which takes the place of
observing a switch position, shall be provided for all such functions
controlled by the keyboard. The tabular display may be used for such
readback. The layout and functional operation of the data entry devices on
the LDC shall be designed and demonstrated to be compatible with the intended
maintenance and operational usage in the expected operational environment
before the equipment production begins.

3.5.16.19 LDC Self-Test.- The LDC shall be able to test itself, check the
test data against established norms, and report the results of the check, if
appropriate, on the tabular display. All tests shall be able to be manually
initiated from the front panel.

3.5.16.20 PPI Display Self-Test.- The PPI video and data inputs shall be
able to be tested by injecting an internally-generated test waveform with a
frequency of approximately 10 KHz into each input individually. The waveform
shall be such that correct action of the slicer associated with the applicable
video input can be observed on the display. Simulated range and azimuth data
shall be available within the LDC to check operation of the display in the PPI
and the RAPPI modes. A capability to generate any type of digital data input
received from the ARSR-4 output buffers shall be provided to test the RAPPI
display. All RAPPI symbols, and their refreshment, shall be able to be tested
using internally-generated test message inputs.

3.5.16.21 Tabular Display and Data Entry Device Self-Test.- A lamp-test or
equivalent exercise of all of the display's output units shall be provided.
Using the tabular display, the correct operation of the keyboard and any other
similar data entry device shall be able to be demonstrated.

3.5.17 ARSR-4/ATCBI-5 Interface Requirements.- The ARSR-4 shall be designed and built to meet the performance requirements specified in 3.4 with the data received from an ATCBI-5 using the formats specified in the following paragraphs, without modification to the ATCBI-5 equipment or its interface requirements. Signal conditioning capabilities shall be provided as necessary to meet these requirements over interconnecting cables of at least 300 feet in length. Isolation which is adequate to prevent damage to (or failure of) the ARSR-4 from occurring as the result of open or short circuits or the application of spurious voltages of up to +/-1000V (from source impedances as low as 1,000 Ω) on any or all of the ARSR-4 interconnecting cables shall be provided. Unless otherwise specified, the interface cabling shall consist of coaxial cables with the correct characteristic impedance for the signal it is to carry.

3.5.17.1 Input Video.- The beacon input video shall be from the ATCBI-5. The beacon video will be a serial video data stream which will contain the aircraft code train replies. The video will be realigned to remove the short stagger which may have been introduced by the beacon interrogator, but will remain staggered as the result of the external stagger requirements of 3.5.17.3. The video will be synchronized with the beacon pair trigger. The video will have been subjected to the effects of Gain Time Control (GTC) circuitry in the receiver (ahead of the quantizer). The nominal and extreme characteristics of the quantized video will be as follows:

	Nominal	Extreme
Amplitude	+4.0 V	+1.0 to +8.0 V
Baseline	0.0 V	-1.0 to +1.0 V
Pulse Duration	0.45 μsec	0.1 to 2.0 μsec*
Rise Time	0.08 μsec	0.05 to 0.2 μsec
Fall Time	0.15 μsec	0.05 to 0.3 μsec
Impedance	75 Ω	70 to 80 Ω
Noise	+0.1 V	+0.2 V maximum

* Note: The wider pulsewidths reflect the widths that may result from overlapped pulses in the replies from two or more aircraft. The width of noninterfering pulses will not exceed 0.60 μsec.

3.5.17.2 Beacon Mode Pair Triggers.- The ARSR-4 shall accept the beacon mode
pair triggers generated within the beacon interrogator and use them to
determine the range and beacon mode of the aircraft's video reply trains. The
triggers will consist of a single pair of pulses per sweep, the separation of
which will indicate the mode of that radar sweep. The first pulse to occur is
designated P1 and the last pulse is P3. P3 is stationary with respect to
beacon zero range. Any interlace sequence or combinations of
Modes 2, 3/A, and C may be provided by the beacon radar. The nominal and
extreme characteristics of the beacon mode pair triggers will be as follows:

	Nominal	Extreme
Amplitude	+15 V	+10 to +60 V
Baseline	0.0 V	-0.5 to +0.5 V
Width	1.0 μsec	0.5 to 2.0 μsec
Rise Time	0.08 μsec	0.15 μsec maximum
Fall Time	0.3 μsec	0.5 μsec maximum
Pulse Spacing (P1 to P3)		
Mode 2	5 μsec	4.8 to 5.2 μsec
Mode 3/A	8 μsec	7.8 to 8.2 μsec
Mode C	21 μsec	20.8 to 21.2 μsec
Impedance	75 Ω	70 to 80 Ω

3.5.17.2.1 Mode 4 Requirements.- BTP performance peculiar to Mode 4
operation is described in 3.5.20.

3.5.17.3 ATCBI Beacon Trigger Requirements.- The ARSR-4 shall provide three
separate trigger outputs to the ATCBI system time coincident with a subset of
the primary radar transmission trigger. The subset shall be selected to
provide a PRT of approximately 3150 μsec. The time between any two triggers
shall not be less than 2800 μsec. The first shall be a nonstaggered radar
range zero trigger. The second shall be a nonstaggered pretrigger 100 μsec
prior to range zero. The third trigger shall be a four period staggered
pretrigger with a minimum pulse to pulse time period difference between pulses
of 50 μsec. The pretrigger/trigger timing shall be site adjustable to
+/-50 percent in one μsec increments over the range of the adjustment.

3.5.17.3.1 ATCBI Beacon Trigger Characteristics.- The trigger pulses shall
have the following characteristics:

    (a)   Polarity: Positive

    (b)   Duration: 0.3 to 2.5 μsec

    (c)   Amplitude: 5 to 50 V peak across 75 Ω input
                             terminating resistor

    (d)   Rise time: Not more than 20 percent of pulse duration

3.5.18 ARSR-4/Mode S Interface Requirements.- The following paragraphs shall be used by the contractor in the design of the ARSR-4 interface with the Mode S system without modification to the Mode S equipment or its interface requirements.

3.5.18.1 ARSR-4 Search Target Extraction Function To Mode S.- There shall be dual sets of isolated data lines from the ARSR-4 search target extraction function to the Mode S sensor. Each link shall be capable of handling the data generated by the ARSR-4 and provide to the Mode S all surveillance data with a delay of no greater than 350 msec after passing the target boresight position. Data shall be transmitted at a rate of 0.5 MHz.

3.5.18.2 ARSR-4/Mode S Communication Interface Characteristics.- The electrical and mechanical characteristics of the communication interface shall conform to a subset of EIA-RS-530. This interface shall be a category I circuit with the balanced electrical characteristics as specified in EIA-RS-422.

3.5.18.3 ARSR-4/Mode S Link Control Level.-

3.5.18.3.1 Procedures.- The surveillance data-communications link level protocol to be used between the ARSR-4 and the Mode S sensor shall be the bit-oriented Advanced Data Communications Control Procedure (ADCCP) as per ANSI X3.66. The ADCCP provides for three classes of procedures. Only one of these is required for this application and is as follows: Asynchronous Balanced Mode (ABM) - Under such procedures, each of the two stations on a point-to-point link is a combined (primary and secondary) station. As appropriate, either of the two stations can take on the primary role (send commands), causing the other to take on the secondary role (send responses).

3.5.18.3.2 Information Field.- The information field contains the search target extraction output messages. These messages consist of ARSR-4 target reports, status, and alarm reports as specified in 3.5.18.4. These reports are placed in the information field singly.

Only one report shall be allowed within each ADCCP frame. It is not permissible to split a report across two or more frames. Data output words are transmitted starting with their MSB.

3.5.18.3.3 Control Functions.- The search target to Mode S interface control is a simplified subset of the ADCCP control protocol, and can be considered a simplex circuit. No data retransmission shall be allowed under any circumstances.

3.5.18.4 Message Level.-

3.5.18.4.1 Code Set.- The information fields of the search target transmission shall be constructed using transparent binary. No code structure (such as ASCII) is to be used.

3.5.18.4.2 Message Format.- Two types of messages are sent from the ARSR-4 to the Mode S. They are target reports, and status and alarm reports. These are described in the following paragraphs.

3.5.18.4.3 Target Report.- The target report message consists of data from the search target extraction function via the first function of the scan to scan correlator as defined in 3.5.7. This report and its format shall be defined by the ARSR-4 contractor and incorporated into the ARSR-4 only after it has been demonstrated to be fully compatible with the data transmission capabilities and data requirements and utilization of all end users (e.g., SOCC, ARTCC, USN, etc.).

3.5.18.4.4 Status and Alarm Report.- At least one status report and one alarm report shall be sent from the ARSR-4 to the Mode S on each scan. If a change in the ARSR-4 status or an ARSR-4 alarm occurs, a status or alarm report shall be transmitted from the ARSR-4 to Mode S within one scan.

Neither the format nor the contents of the status and alarm report has been defined. This report and its format shall be defined by the ARSR-4 contractor and incorporated into the ARSR-4 system only after it has been demonstrated to be fully compatible with the data transmission capabilities and data requirements and utilization of all end users (e.g., SOCC, ARTCC, USN, etc.).

3.5.18.5 Mode S Reinforce Function to the ARSR-4 Editing Function Interface.-

3.5.18.5.1 Physical Control Level.-

3.5.18.5.1.1 Communication Links.- There shall be a dual set of isolated communication links from each Mode S surveillance processing channel to the ARSR-4 for editing. Each communication link shall be capable of handling the data rate generated by the Mode S. Data shall be transmitted over both links simultaneously provided both Mode S surveillance processing channels are available. Data shall be transferred at a rate of 0.5Mbps.

3.5.18.5.1.2 Communication Interface Characteristics.- The electrical and mechanical characteristics of the communication interface shall conform to EIA-RS-530. This interface shall be a category I circuit with the balanced electrical characteristics as specified in EIA-RS-422.

3.5.18.5.2 Link Control Level.-

3.5.18.5.2.1 Procedures.- The surveillance data-communications link level protocol to be used between the Mode S and the ARSR-4 for editing function shall be the bit-oriented ADCCP as per ANSI x3.66. The ADCCP protocol provides for three classes of procedures. Only one of these procedures is required for this application, namely, the ABM which is as follows:

ABM - Under such procedures, each of the two stations on a point-to-point link is a combined (primary and secondary) station. As appropriate, either of the two stations can take on the primary role (send commands), causing the other to take on the secondary role (send responses).

3.5.18.5.3 Information Field.- The information contains the following message types. Each message is placed in the information field singly. The messages listed below shall include all applicable data defined in 3.5.13.

(a) Target reports identical to the reports sent to Mode S. These reports represent reports that did not reinforce a Mode S beacon report. These reports are also referred to as radar-only reports.

(b) Mode S/radar reinforced reports which contain beacon ID field bits; including tag bits like IDENT, REINFORCEMENT, EMERGENCIES, AND CODE VALIDATION BITS. Also contained in this report are range, azimuth, Mode 3/A, 2 and C codes, and other target report data established by 3.5.18.4.3. These reports are also referred to as radar beacon merge messages.

(c) Mode S beacon reports which contain beacon ID field, tag bits, range, azimuth, and Mode 3/A, 2 and C codes. These reports are also referred to as beacon-only messages.

(d) ARSR-4/Mode S status which contains the status of the ARSR-4 which ARSR-4 sends to Mode S and appended to this message is the status of Mode S.

3.5.18.5.4 Control Functions.- The Mode S/ARSR-4 editing function interface control shall be a simplified subset of the ADCCP control protocol, and can be considered a simplex circuit. No data retransmission shall be required from Mode S under any circumstances

3.5.18.5.5 Message Level.-

3.5.18.5.5.1 Code Set.- The information fields of the Mode S transmissions are constructed using transparent binary. No code structure (such as ASCII) is used.

3.5.18.5.5.2 Message Format.- There are four types of messages sent from the Mode S to the ARSR-4 as follows:

    (a)   Radar-only reports

    (b)   Beacon/Radar reinforced reports

    (c)   Beacon-only reports

    (d)   ARSR-4/Mode S status messages, as specified in 3.5.18.5.3

The actual format of the data in the information field is the responsibility of the contractor and details of the format shall be included in an interface control document developed by the contractor.

3.5.18.6 Data Switch Requirements.- When the ARSR-4 is operating with a Mode S Interrogator, the ARSR-4 shall continuously monitor the Mode S on-line channel signal. In the event of a Mode S surveillance processing channel failure or a Mode 4 request and interrogation, the ARSR-4 shall automatically switch to a mode in which the Mode S quantized beacon video is provided to the ARSR-4 and processed in a manner similar to the quantized beacon video received from an ATCBI-5. Appropriate status signals shall be provided to the RMS to indicate when the ARSR-4 has taken over the beacon processing function.

3.5.18.6.1 Mode 4 Data Switch Requirements.- When Mode S is fully operational, Mode 4 requests shall take precedence in that one Mode S transmitter and antenna shall be committed to Mode 4 operation on demand. In addition, all the BTP functions during the Mode 4 operation shall be provided, including test target generation and diagnostics.

3.5.18.7 Mark XV Requirements.- The ARSR-4 shall be capable of Mark XII request and reply processing, as described in DOD AIMS 65-1000, on aircraft equipped with Mark XV transponders.

3.5.18.8 Staggered Mode S Beacon Trigger.- The ARSR-4 shall provide two separate trigger outputs to the Mode S system. The first shall be a radar range zero trigger time coincident with the radar transmission. The second trigger shall be a four period staggered pretrigger with a minimum pulse to pulse time period difference between pulses of 50 μsec. The trigger average PRF shall be field adjustable +/-5 percent in increments of 1 percent or less.

3.5.19 Radar Remote Weather Display System (RRWDS) Interface.- The ARSR-4 shall be designed and built to meet the performance requirements specified in 3.5.12.2.1 and shall provide video, pretrigger, ARP/ACP data, and status signals in accordance with the following subparagraphs. Signal conditioning capabilities shall be provided as necessary to meet these requirements over interconnecting cable length of up to 300 feet. Isolation which is adequate to prevent damage to (or failure of) the ARSR-4 from occurring as a result of open or short circuits or the application of spurious voltages of up to +/- 1000V (from source impedances as low as 1,000 Ω) on any or all of the input ports, of the RRWDS shall be provided. The interface cable for the video, pretrigger, and ARP/ACP signals shall be RG-59U with VG-260C/W connectors at the RRWDS inputs.

3.5.19.1 Weather Log Video.- The input weather log video from the ARSR-4 at the input to the RRWDS shall have the following characteristics:

    (a)   Amplitude: +2 to +5V

    (b)   Impedance: 75 Ω

    (c)   Type: Analog log video

3.5.19.2 Pretrigger.- The pretrigger from the ARSR-4 at the input to the RRWDS shall have the following characteristics:

    (a)   Amplitude   +5 to +30 V

    (b)   Timing   1 to 200 µsec prior to radar time zero

    (c)   Pulse duration   0.5 to 2 µsec

    (d)   Rise time   0.15 µsec maximum

    (e)   Impedance   75 Ω

3.5.19.3 Azimuth Reference Pulse (ARP)/Azimuth Change Pulse (ACP).- The ARP/ACP data from the ARSR-4 at the input to the RRWDS shall have the following characteristics:

    (a)   Amplitude   +5V minimum

    (b)   Rate   4096 ACPs per revolution
                                 One ARP per revolution

    (c)   Impedance   75 Ω

3.5.19.4 Status Signal.- In the event that the ARSR-4 design has a dual
channel weather receiver and/or processor, the following status signals shall
be provided at the input to the RRWDS:

    (a)   Channel A: On   Ground

                                Off   +5 VDC or +12 VDC

    (b)   Channel B: On   Ground

                                Off   +5 VDC or +12 VDC

    (c)   Impedance: 10 KΩ

3.5.19.5 Optional Interfaces.- The contractor may elect to interface with
RRWDS at other than the specified analog log video input if it can be shown
that this in no way degrades the data output from the RRWDS. Any modification
required of the RRWDS to accommodate this interface shall be accomplished by
the contractor as part of the ARSR-4 effort, including the necessary changes
to the RRWDS documentation to reflect the modification(s).

3.5.20 Mode 4 Interface.- The ARSR-4 shall provide for operation with Mark
XII modes 2, 3/A, C, and 4, and Mode S (for sites equipped with Mode S). All
beacon requirements (including the beacon capacity requirements) stated herein
apply to the Mode 4 function unless otherwise stated in the following
subparagraphs. The Mark XII modes shall include the provision of video
outputs from the BTP, with the technical characteristics detailed in DOD AIMS
65-1000B. The technical characteristics and requirements for Mode 4 operation
are provided in the following subparagraphs.

The data lines to/from the ARSR-4 site and SOCC will be encrypted for
transmission to protect the Mode 4 friend level (D1/D2) information.

3.5.20.1 Mode 4 Peculiar External Interface Equipment.- The following equipment shall be used as specified herein.

(a) Mode 4 computer, KIR-1B or KIR-1C - Provides encryption of Mode 4 interrogations and validation of Mode 4 replies as specified in DOD AIMS 64-900D.

(b) Interface Device KG-84C - Provides interfaces between the USAF modems and message formatter and provides encryption of data between the ARSR-4 and the SOCC. The interface device characteristics are as specified in the KG-84C Performance and Interface Specification.

(c) Remote Rekeying Device, known as either the Generic Remote Rekeying System (GRRS) or the FARR/IADS Remote Rekeying System (FIRRS) - Provides control of rekeying of the KG-84C interface device and the KIR-1B or KIR-1C.

All encryption and decryption of message traffic to/from the SOCC will be accomplished by the KG-84C interface device. All rekeying functions of the KIR-1B or KIR-1C and KG-84C will be performed by the Government key management hardware (GRRS or FIRRS).

3.5.20.2 Mode 4 Performance Requirements.- The beacon performance requirements of 3.4.2 apply to the Mode 4 operation except as described in the following subparagraphs.

3.5.20.2.1 Mode 4 Requirements.- When using Mode 4 only, the probability of detection in 3.4.2.3 shall equal the specification values stated for primary mode only responding for 4, 6 and 8 interrogations. For 11, 15 and 23 interrogations, the values shall be 0.95. When using Mode 4 simultaneously with Modes 2, 3/A, and C; the probability of detection for Mode 2, Mode 3/A, and Mode C shall not be degraded.

3.5.20.2.2 Code Validation.- When using Mode 4 only, the friend evaluation specified in 3.5.20.3.2.2 shall be achieved at least 95 percent of the time.

3.5.20.2.3 Mode 4 Azimuth Resolution.- The requirements of 3.4.2.6 shall apply to Mode 4 targets with the following clarifications when operating Mode 4 only or when operating Mode 4 simultaneously with Modes 2, 3/A, and C:

(a) With 18 PRTs or more separation, the Mode 4 targets shall be distinguishable in azimuth 95% of the time.

(b) With less than 11 PRTs separation, two Mode 4 responses are not required to be resolved.

(c)   When one target does not respond to a Mode 4 interrogation and another target does respond to a Mode 4 interrogation, the Mode 4 response shall be distinquishable and reinforce with the correct target 99.5% of the time.

3.5.20.3 Mode 4 Detailed Performance and Design Requirements. - Figure 3-6 is a block diagram of the Mode 4 Function, and Figure 3-7 shows more detail on the external interfaces. Functions of the Mode 4 processor and the KIR-1B or KIR-1C are described herein. These figures are provided for explanation purposes only and do not imply any pre-supposed design.

The contractor shall provide two NSA-approved security containers (Mosler or Hamilton, Model #54-50 for either company) for housing the KIR-1B or KIR-1C, the GRRS or FIRRS, and six KG-84Cs. The contractor shall provide a power distribution panel (with external power cable) and cooling for the equipment within each of the security containers. The cooling system shall provide for closed door operation of the equipment within the security container. Each container shall have an overtemp sensor to report overtemp conditions to the SOCC and RMS. In addition, the contractor shall supply a Time of Year Clock input to the security container for use by the GRRS or FIRRS. The contractor shall provide the interconnect cabling between the ARSR-4 equipment and the KIR and the KG-84Cs. The contractor shall also provide AC power wiring to and inside each container. The contractor shall provide the AC power wiring from the power distribution panel to the KIR-1B or KIR-1C and to the contractor-furnished equipment within the containers. The Government shall provide the AC wiring from the power distribution panel to all EIE within the containers other than the KIR-1B or KIR-1C. Switch wiring, door open sensing, and over-temperature sensor wiring shall be provided by the contractor inside the containers and to the ARSR-4. The Government shall be responsible for all other cabling and wiring inside, between, and to the containers. RS-530 interconnects will be used with the data processor configured as Data Terminal Equipment.

The contractor shall provide a switch panel within the security container containing switches to enable a number of Mode 4 functions including:

(a)   Selection of evaluator mode,
(b)   Enabling of D1-D2 bits to the LDC,
(c)   Selection of the A/B code,
(d)   LDC Mode 4 Control Switch,
(e)   Port Assignment Switch, and
(f)   ISLS Pulse

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Figure 3-6, ELEMENTARY DIAGRAM
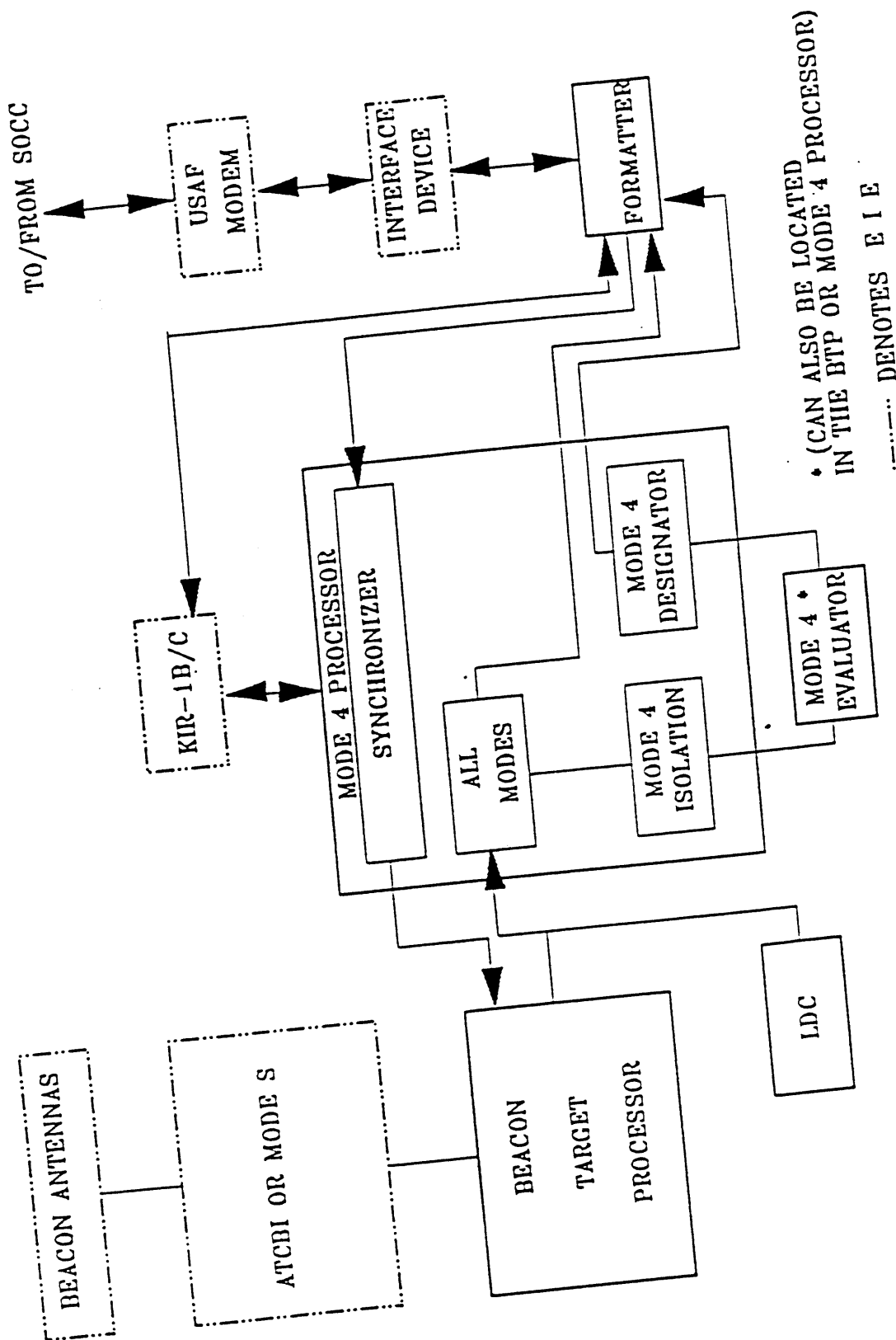
* (CAN ALSO BE LOCATED
IN THE BTP OR MODE 4 PROCESSOR)

------ DENOTES E I E

Figure 3-7, MARK XII MODE 4 INTERFACE BLOCK DIAGRAM
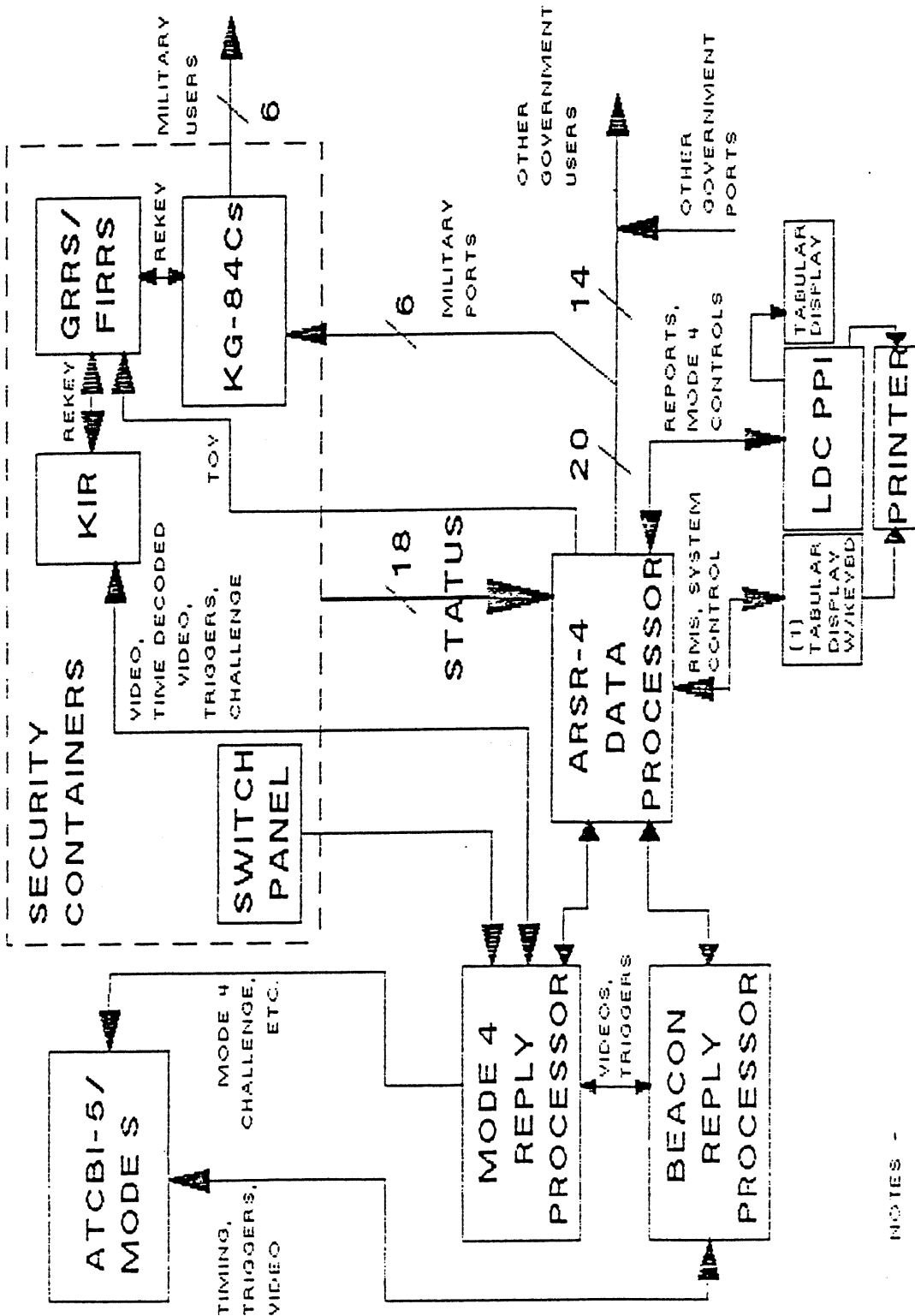
NOTES -

(1) ONLY WITH MASTER LDC

3.5.20.3.1 Mode 4 Enabling.- The interface between the SOCC and the ARSR-4 shall provide for actuation of Mode 4 operation from the SOCC. In addition, it shall be possible to enable the Mode 4 operation from within the ARSR-4 site at the LDC. The purpose for this latter function is to permit local control of Mode 4 operation during on-site maintenance and autonomous operation. The local enable capability shall fully duplicate the enable functions of the SOCC. Mode 4 enabling is accomplished by grounding a control lead connected to the KIR-1B/KIR-1C in accordance with DOD AIMS 64-900D. This grounding action shall be activated by Mode 4 request messages from the SOCC and the LDC, and shall provide for both automatic sector control and manual operation. Manual enabling shall be possible through a spring loaded, manually operated challenge switch located at all LDCs. Figure 3-8 shows how Mode 4 enabling may be performed between the SOCC and the LDC. Mode 4 challenges shall utilize the same antenna subsystems used for ATCBI-5 and Mode S. This figure is provided for information purposes only and does not imply any presupposed design.

3.5.20.3.1.1 Enabling Functions at the SOCC.- The enabling functions for Mode 4 operation at the SOCC shall have, but not be limited to, the following:

> Enabling the Mode 4 manually by operator actions.
> Enabling the Mode 4 by automatic sector operation.

Manual and computer directed selection of center azimuth is transparent to the ARSR-4. Start/Stop azimuth will be sent to the ARSR-4 system. The format resulting from the selection is the 91 bit modified CD-2 format.

> Selection of center azimuth (manual or computer directed).
> Selection of the first three above without interfering with SOCC operation of Modes 2, 3/A, and C.

Whenever Mode 4 operation of the ARSR-4 is requested, the modulation pulses from the KIR-1B/KIR-1C shall be fed via the Mode 4 processor and the BTP to the ATCBI-5 or Mode S for the production of RF pulse train signals. The shape and tolerances of the modulation and RF signals shall be in accordance with DOD AIMS 64-900D and DOD AIMS 65-1000B. The radiation of the Mode 4 signals shall continue only for the duration of the enabling of the KIR-1B/KIR-1C and shall cease immediately with the cessation of the modulation signals from the KIR-1B/KIR-1C.

3.5.20.3.1.2 Enabling the Mode 4 at the ARSR-4 Site.- It shall be possible to operate all of the above Mark XII enabling functions (including Mode 4) from within the site of the ARSR-4. These functions shall be made possible through the installation and use of one or more displays (3.5.16). There shall be an automatic change-over of the control functions when the LDC(s) is (are) placed into operation. When operating from the LDC(s), there shall be no deleterious effects placed on the SOCC interfaces due to the change-over of the controls. When the ARSR-4 is being controlled by the LDC(s), an alarm signal shall be automatically sent back to the RMS, to indicate that the control of the ARSR-4 is not available to the SOCC operating positions. Upon subsequent disabling of the LDC(s) and return of the control to the SOCC, the alarm signals shall be automatically removed.
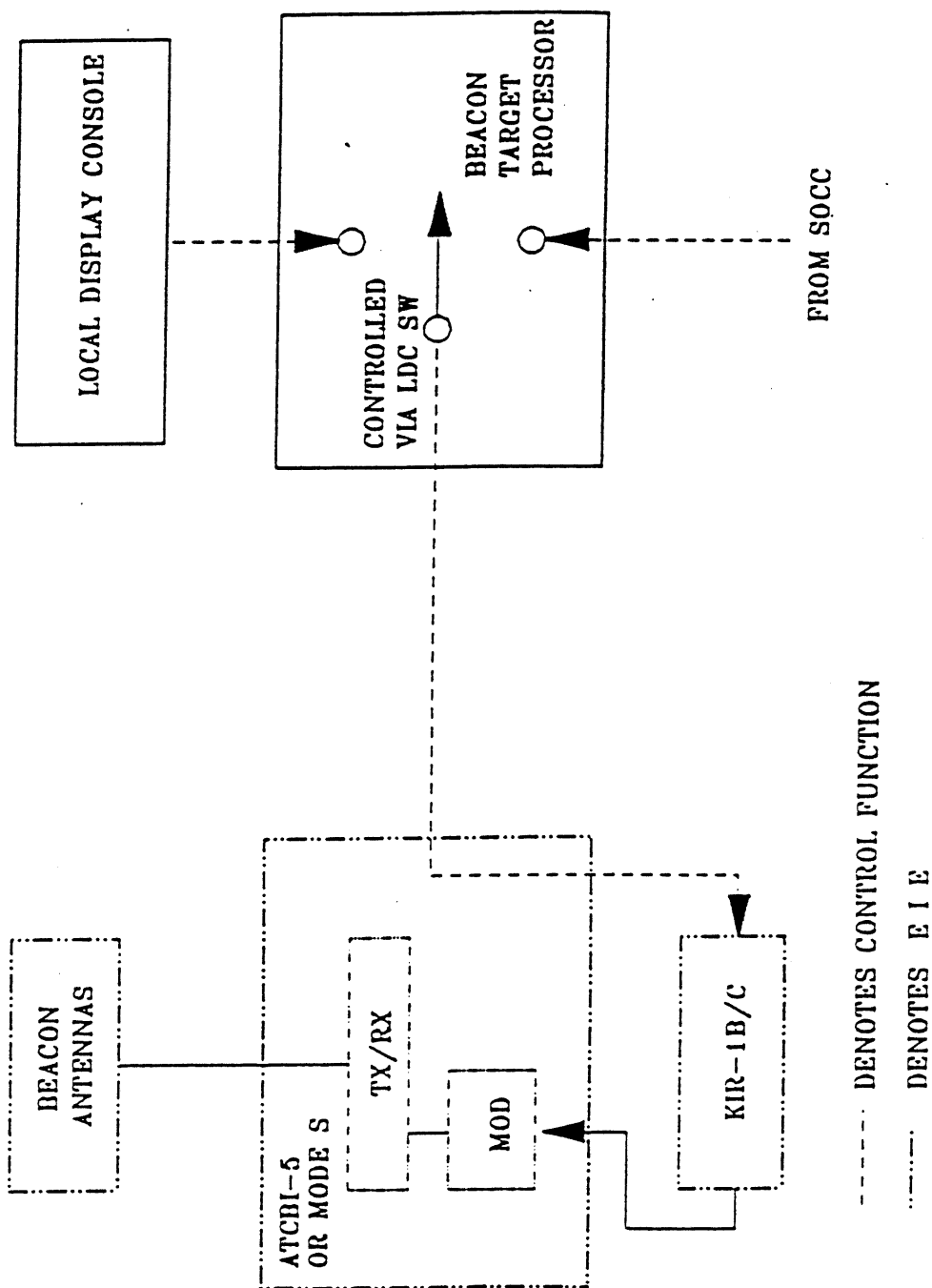
Figure 3-8, MODE 4 ENABLING

3.5.20.3.1.3 Sector Operation of Mode 4.- Sector enabling may be a function of the BTP or the Mode 4 Processor. It shall be possible to select sector operation from the SOCC and the ARSR-4 LDC(s) with the sector centered over any selected azimuthal position. A separate control such as an enable line or switch control shall be provided for 360 degree operation.

3.5.20.3.1.3.1 Mode 4 Sector Enabling.- Sector control of the Mode 4 shall be done by enabling the circuits of the KIR-1B/KIR-1C, in accordance with DOD AIMS 64-900D. Sector control shall be performed by selecting an azimuth position and having the sector start before and center over the chosen azimuth. The sector width shall be 10 degrees (sector azimuth +/-5 degrees). When 360 degree operation is desired, it shall be made available through a separate (momentary type) control function.

3.5.20.3.1.3.2 Mode 4 Provisions for Operational Regulations.- Provisions shall be made in the ARSR-4 design to automatically send an alarm via RMS to the MPS and inhibit the Mode 4 operations during the following situations.

(a) When 360 degree operation is initiated and in use

(b) When Mode 4 is initiated and conflicts with any of three site selectable sectors. The sector azimuths and widths shall be site adjustable in one degree increments over the entire 360 degree coverage volume.

The design of the ARSR-4 shall provide a simple means for bypassing the alarm and the inhibition of the Mode 4 operation at the ARSR-4.

3.5.20.3.1.4 Enabling Mode 4 Along with Modes 2, 3/A, and C.- Both of the following Mode 4 operating modes shall be selectable from the SOCC. The BTP shall be capable of suitable operation with both (a) and (b).

(a) When the Mode 4 is enabled, the Mode 4 signals shall be combined and radiated simultaneously with any of the operating Modes 2, 3/A, or C. Mode S shall be inhibited on the front beacon antenna, but may radiate on the back beacon antenna in Mode S Beacons. In meeting all of the requirements specified herein, the contractor shall take into account any mutual interference effects induced by any of the beacon antennas radiating, regardless which of the three beacon antenna configuration is used. This form of dual mode operation is sometimes indicated as Super Mode, and is the normal mode of operation. Super Mode and Mode 4 interrogation-reply timing details are provided in Figure 3-9.

(b) When Mode 4 is enabled; Modes 2, 3/A, C, and S (in Mode S Beacons) that are operational shall be inhibited (disabled) for the duration of the Mode 4 operation. The inhibited modes shall instantly and automatically resume at the completion of the Mode 4 operation. This is a special mode of operation.

-123-

CHALLENGE

72 USEC

REPLY

64 USEC
(REPLY JITTER)

MODE 4 ONLY

CHALLENGE

ANY MODE
2, 3/A,C

72 USEC

REPLY

ANY MODE
2, 3/A,C

20.3 USEC

5-21 USEC

64 USEC
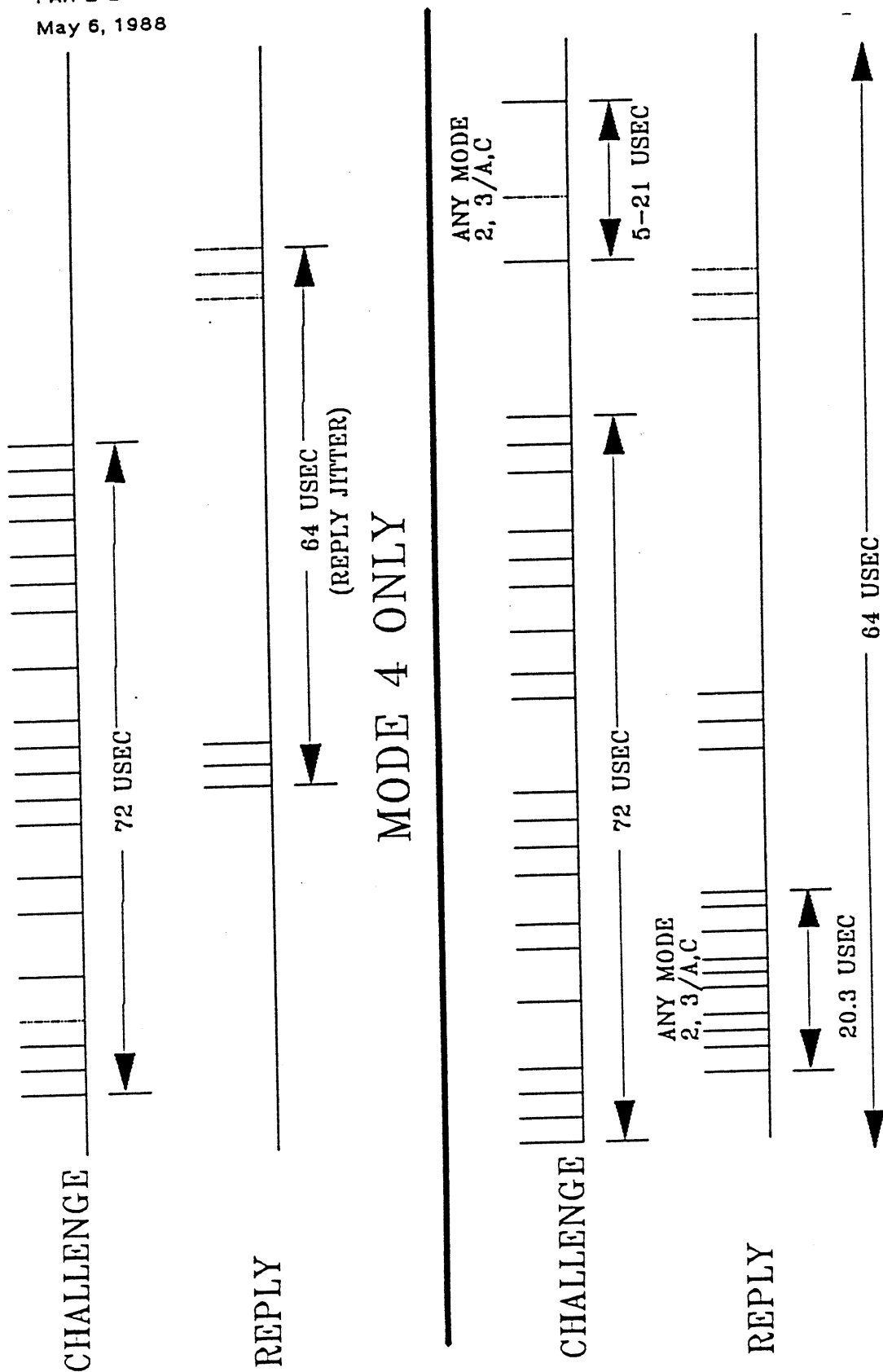
Figure 3-9, MODE 4 WITH MODES 2, 3/A, AND C

3.5.20.3.1.4.1 Synchronization.- The system shall synchronize all mode and SIF interrogations so that there shall be no interference between interrogations or replies for either airborne or ground operations relative to the same target. The timing characteristics of the SIF pretrigger shall be as follows:

(a) Pulse Width   0.5 to 10.0 μsec

(b) Frequency   200 to 450 pps

3.5.20.3.1.4.2 PRF.- The average PRF of the SIF pretriggers shall not exceed 450 pps as specified in DOD AIMS 65-1000B.

3.5.20.3.1.4.3 Mode 4 Pretrigger Jitter.- The Mode 4 pretrigger shall always be inhibited if the jitter on the input SIF pretrigger is greater than 0.4 μsec. If the jitter is less than 0.2 μsec, the Mode 4 pretrigger shall always be generated. The range between 0.2 and 0.4 μsec is a gray region due to timing system tolerances and quantizing effect of the digital counters. This feature may be bypassed by activating a switch on the synchronizer so that challenges may be sent even when the jitter exceeds 0.4 μsec.

3.5.20.3.1.4.4 ATCRBS SIF Interrogation.- The ATCRBS SIF interrogation input pulse characteristics shall be in accordance with 3.4.2.2.

3.5.20.3.1.4.5 Not Used.-

3.5.20.3.1.4.6 Not Used.

3.5.20.3.1.4.7 Mode 4 Challenge Signal.- The Mode 4 pretrigger shall cause the system to generate the Mode 4 challenge signal if the Mode 4 enable gate is present. The Mode 4 challenge signal shall be in accordance with DOD AIMS 64-900D.

3.5.20.3.1.4.8 Mode 4 Interrogator Sidelobe Suppression (ISLS).- The system shall generate a Mode 4 trigger which shall be adjustable in position between the fourth synchronous pulse and the first information pulse position of the Mode 4 interrogation pulse train. A switch shall be provided which shall cause the Mode 4 ISLS trigger to appear on a separate output jack or be mixed with the Mode 4 challenge pulse train at the same output with the Mode 4 challenge pulse train. The Mode 4 ISLS pulse characteristics shall be in accordance with DOD AIMS 65-1000B.

3.5.20.3.1.4.9 Mode 4 Gain Time Control (GTC) Trigger.- The system shall provide a Mode 4 GTC trigger having the following characteristics:

    (a)   Pulse Duration   0.3 to 1.5 μsec

    (b)   Rise Time   0.1 μsec, maximum

    (c)   Fall Time   0.3 μsec, maximum

    (d)   Amplitude   +3 to 5 VDC

    (e)   Baseline   0 ± 1 volt DC

    (f)   Impedance   90 Ω

    (g)   Timing   372 ± 0.5 μsec following M4 pretrigger

3.5.20.3.1.4.10 Mode 4 Video Suppression Gate.- The system shall provide a Mode 4 video suppression gate output. The video suppression gate shall have the following characteristics:

    (a)   Duration   2 to 100 μsec

    (b)   Rise Time   0.5 μsec, maximum

    (c)   Fall Time   1.0 μsec, maximum

    (d)   Timing   Within 0.5 μsec of the first synchronous pulse of the challenge train.

    (e)   Amplitude   +5 to 50 VDC

    (f)   Baseline   0 ± 1 volt DC

    (g)   Impedance   90 Ω

The video suppression gate shall be timed relative to the Mode 4 KIR trigger to occur nominally 0.5 μsec prior to the Mode 4 challenge video.

3.5.20.3.1.4.11 Noise Jitter PRF.- The system shall generate a new SIF pretrigger adjustable from 286 to 444 μsec following receipt of a jittered SIF pretrigger. The delayed SIF pretrigger shall have the following characteristics:

    (a)   Pulse Duration   0.5 to 2.0 μsec

    (b)   Rise Time   0.1 μsec, maximum

(c)	Fall Time	0.2 μsec, maximum
(d)	Jitter	+/- 0.1 μsec, maximum
(e)	Amplitude	+5 to 50 VDC
(f)	Baseline	0 ± 1 volt DC
(g)	Impedance	90 Ω

3.5.20.3.1.4.12 Internal Trigger.- The system shall have self-test circuitry and use it to validate the presence of the Mode 4 pretrigger.

3.5.20.3.1.4.13 Mode 4 Pretrigger.- The system shall generate a Mode 4 pretrigger 354 μsec, +/-0.1 μsec ahead of the time for a zero range ATCRBS SIF reply. The pretrigger shall be correctly generated for any fixed PRF between 200 pps and 450 pps and for any two-cycle staggered PRF.

3.5.20.3.1.4.14 Super Mode Pretrigger Signal.- When in the Super Mode of operation, the system shall generate a signal simultaneously with the Mode 4 pretrigger to indicate Super Mode (as opposed to Mode 4 only) operation.

3.5.20.3.1.4.15 Readout Delay.- The system shall include a timing site adjustment that permits a zero range target to be delayed with respect to the SIF pretrigger from a minimum value of 8 μsec to a maximum of 98 μsec.

3.5.20.3.1.4.16 Mode 4 Mode Switch.- The system shall select the interrogation train timing when the synchronizer (which sends the timing trigger signals to the BTP) is used in automatic, Super Mode, or manual override modes operation. The Mode 4 pretrigger shall be generated 354 μsec prior to SIF zero range. The Mode 4 pretrigger shall be generated 441 μsec prior to zero range.

3.5.20.3.1.5 Mode 4 Loop Test and Self Tests.- The ARSR-4 shall also have provisions for loop testing the Mode 4 function, including the interfaces from the SOCC. The loop testing function shall exercise all of the functions of the Mode 4 hardware units specified herein, except for the following:

(a) Functions of the KIR-1B/KIR-1C which performs its own self checks.

(b) The GRRS or FIRRS equipment rekeying and zeroizing functions.

Loop testing shall be capable of being performed without interruption of normal operation of the Mode 4 function. Failures detected by the loop test, and 18 status lines total from EIE and vault security shall be interfaced to the RMS. The characteristic of each status signal is as follows:

KG-84C Alarm	6 each
KG-84C Transmit ready remote indication	6 each
KIR Lockout light return	1 each
KIR Code zeroize and alarm output	1 each
Vault overtemp	2 each
Vault door open	2 each

The Mode 4 function shall include the provisions necessary for performing all of the Mode 4 tests specified in Paragraph 3.5.15.8.

3.5.20.3.2 Mode 4 Processing Requirements.- The design of the BTP/Mode 4 Processor/Mode 4 Evaluator when interfaced with the KIR-1B/KIR-1C equipment shall perform the following functions:

(a)   Provide synchronization of Mode 4 and SIF interrogations.

(b)   Determine the FRIEND level through a target reply evaluator which performs its evaluations from Time Decoded Video received from the KIR-1B/KIR-1C which receives Mode 4 replies from the ATCBI-5 or Mode S Interrogator. The evaluator for this FRIEND determination may be designed as a separate electronic assembly located near the BTP or may be internal module(s) in the BTP or Mode 4 Processor. The degree of FRIEND determination by the evaluator shall be equal to or greater than the FRIEND determination produced by the algorithm given in 3.5.20.3.2.2.1 which has three designators: TRUE FRIEND, NEAR FRIEND, and POSSIBLE FRIEND.

(c)   Provide a capability for bypassing the Mode 4 evaluator function to supply nonevaluated Mode 4 reply signals. A "non-evaluated Mode 4 reply signal" as used in this context is a Mode 4 video signal. When the evaluator bypass is in effect, Mode 4 messages shall not be sent to the SOCC. Only evaluated Mode 4 reports shall be transmitted to the SOCC via the message formatter. Non-evaluated reply signals shall be made available at the LDC for test purposes. When this bypass function is being utilized, the other Modes of 2, 3/A, and C, as well as the Mode S (for sites equipped with Mode S) shall not be inhibited or otherwise perturbed.

(d)   Provide the Mode 4 signals to the Mode 4 Processor where the Mode 4 signals will be converted to message units and output to the KG-84C for encryption and transmission. Detailed requirements for this output are given in Paragraph 3.5.20.3.2.1.

3.5.20.3.2.1 Mode 4 Processor Functions. - The Mode 4 Processor shall perform the following functions:

(a) Initiate Mode 4 transmission pulse trains in accordance with 3.5.20.3.1.

(b) Separate received evaluated or nonevaluated Mode 4 signals from received Mode 2, 3/A, and C signals.

(c) Convert Mode 4 signals into message items for formatting in the messages specified herein.

(d) Route DOD Mode 4 message items to the message formatter where they shall be buffered and routed for encryption by the KG-84C Interface Device.

(e) Route non-Mode 4 message items to the message formatter where they shall be held, combined with the Mode 4 message items, and routed for transmission to the SOCC through the KG-84C Interface Device and modem. (See Figure 3-6).

The Mode 4 processor shall also have a self-test feature which provides an alarm signal to the RMS in the event of failure of any of its functions.

3.5.20.3.2.1.1 Isolated Mode 4 Output. - Mode 4 signals shall be separated from other reply signals and routed to the KIR-1B/C for decoding. Time decoded signals from the KIR-1B/C shall be routed to the Mode 4 processor for friend level determination.

3.5.20.3.2.1.2 Mode 4 Designator. - The Mode 4 designator shall perform the necessary conversion and digitalization of Mode 4 video to message items and route them to the message formatter, where the non-Mode 4 and the Mode 4 message items are formatted into DOD messages.

3.5.20.3.2.1.3 Mode 4 Synchronizer. - Mode 4 request messages from the SOCC via the Interface Device and USAF modem shall be stored in the Mode 4 synchronizer memory.

The memory shall be capable of storing a total of 21 request messages which shall be used in conjunction with the beacon antenna azimuth data to generate Mode 4 enabling gates for the requested azimuth sectors.

3.5.20.3.2.1.3.1 Not Used. -

3.5.20.3.2.1.3.2 Not Used.-

3.5.20.3.2.1.3.3 Not Used.-

3.5.20.3.2.1.3.4 Not Used.-

3.5.20.3.2.2 Mode 4 Evaluation.- The evaluation of the Mode 4 reply signals is a statistical procedure that searches for a sufficient number of valid responses to a given number of Mode 4 challenges. This evaluation shall be performed either in the separate electronic assembly, the BTP, or the Mode 4 Processor.

The Mode 4 reply signal evaluator shall achieve the following performance:

   (a)   The target identity shall be determined from Mode 4 replies in accordance with the established criteria for Enemy Acceptance (EA) and Friend Rejection (FR) requirements in Appendix B, part I, to this specification.

   (b)   The criteria for EA and FR shall be met in a variety of signal density environments. The correct number of statistical replies for EA and FR shall be determined from an environment sampling procedure having 3 sampling levels. The following level values shall be used:

Environment	Level
Low	0 - 5,000 replies per second
Medium	5,000 - 15,000 replies per second
High	15,000 - 30,000 replies per second

The numerical values represent the total of all modes of target replies. These numbers represent the total synchronized and nonsynchronized (fruit) replies and spoofs. For the purpose of meeting the EA requirement, the specified Mode 4 target environment shall consist of deceptive Mode 4 spoofer aircraft and bonafide Mode 4 aircraft. The Mode 4 reply evaluation algorithm shall take into consideration that some aircraft may employ spoofing techniques consisting of up to eight randomly distributed guesses over each of the 16 possible Mode 4 range time delay positions to enhance their probability of Friend Level identification. In this situation, the deceptive Mode 4 spoofer may appear as eight independent targets and will be counted against the specified Mode 4 target environment. Under momentary conditions of extremely severe target environments (in excess of 30,000 target replies per second within the reception volume), the determination of the EA shall be given greater importance than FR.

The minimum acceptable Mode 4 evaluation capability uses a friend sequential observer technique and three thresholds to evaluate each Mode 4 reply and decide its identification level. If this technique is used for the ARSR-4 design, the interrogation rate shall be variable, to meet the requirements of Appendix B, Part I of this specification in the specified Fruit environment. Several superior methods of target evaluator design have been developed. These methods recognize the Mode 4 environment and automatically verify and designate targets in accordance with the changing environments. One of these superior methods may be used and is preferred.

3.5.20.3.2.2.1 Mode 4 Friend Level Decision.- Each friend level decision shall be in the form of two data bits, D1 and D2, for inclusion in the Mode 4 messages specified previously. Four different levels shall be indicated. D1 alone represents possible friend, D2 alone represents near friend and D1 and D2 together represent true friend. Neither D1 nor D2 represents null or no decision. The thresholds for each friend level shall be selected to meet the requirements of Appendix B, Part I, for the environment specified in 3.5.20.3.2.2. Mode 4 in-line friend processing shall be invoked to resolve four or less Mode 4 targets which have an alignment in range such that they fall into the critical timeslots of other Mode 4 targets throughout the azimuth runlength of the targets.

3.5.20.3.2.2.2 Mode 4 Thresholding.- The variable thresholding for determining the proper FRIEND identity can be a continuous function or the three level step function specified previously. In either method, the selection of the evaluation criteria shall be completed and automatically accomplished through sampling techniques of the BTP. Any method that relies on preset or manual selection for the criteria at either the ARSR-4 site or the SOCC will not be considered acceptable. The duration of the evaluation criteria shall continue only as long as the duration of the governing environment exists. As the environment changes, the correct evaluation criteria shall automatically change. The normal density of the target environment will not be constant throughout a single scan of the ARSR-4 antenna, and succeeding scans may, or may not, duplicate the target densities of the preceding scans. Therefore, the full range of evaluation criteria shall be capable of adapting during a single scan, and re-adapting during successive scans.

3.5.20.3.2.3 KIR-1B/KIR-1C Functions.- The KIR-1B or KIR-1C will perform the following operations:

    (a)   Generate Mode 4 modulation pulses in response to Mode 4 challenge directions received from either the SOCC or the LDC in accordance with 3.5.20.3.1.

    (b)   Time-decode Mode 4 replies.

Details on the operation and interfaces of the KIR-1B/KIR-1C are provided in DOD AIMS 64-900D. The KIR-1B or KIR-1C will eventually replace the KIR-1A, which will allow an electronic (rather than mechanical) rekeying capability through the Interface Device and formatter.

3.5.20.3.2.4 Formatter Mode 4 Functions.- The formatter shall perform the functions specified in the following subparagraphs.

3.5.20.3.2.4.1 General.- The formatter shall provide:

(a) Recognition and routing of all Mode 4 request messages from the SOCC as specified herein.

(b) Time of Year (TOY) clock time code to the GRRS/FIRRS. Interface of TOY to GRRS/FIRRS shall be defined by the ARSR-4 contractor.

All encryption and decryption of message traffic to/from the SOCC will be accomplished by the interface device.

3.5.20.3.2.4.2 Detailed Requirements.- The formatter shall perform the following functions in conjunction with the KIR-1B or KIR-1C:

(a) In the event of Mode 4 equipment or communication link failure, generate a fault/status indication which is transmitted to the SOCC prior to the completion of the next full radar scan, i.e., within 12 seconds.

(b) Provide the status of the EIE equipment housed in the security containers to the SOCC as part of the status message sent to the SOCC.

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3.5.20.4 Mode 4 Interface Function.- The Mark XII Mode 4 interface function
shall provide all of the internal and external interfaces for the Mark XII
Mode 4 function between the SOCC and the ATCBI-5 or Mode S Beacon
Interrogator. Requirements for these interfaces are provided below. Control
of Mode 4 operation and receipt of Mode 4 information is accomplished at the
SOCC through transmission and reception of messages as specified in 3.5.13.
All data in the Mode 4 messages between the ARSR-4 and the SOCC will be
encrypted and decrypted by the KG-84C Interface Device. The Mode 4 interfaces
and subsystem and system interconnections presented by this specification are
functional. Variations in actual design will be acceptable if they meet the
performance requirements specified herein and are electrically and physically
compatible and interoperable with the EIE.

3.5.20.4.1 Interface Block Diagrams.- The simplified diagrams presented
herein identify the functions and basic interconnections between the Mode 4
and associated units of the ARSR-4. Figure 3-11 presents the elementary
interfaces for the Mode 4 Function with their descriptions following the
diagram. There has been no attempt to identify all of the operational
functions via this drawing, nor imply any particular design.
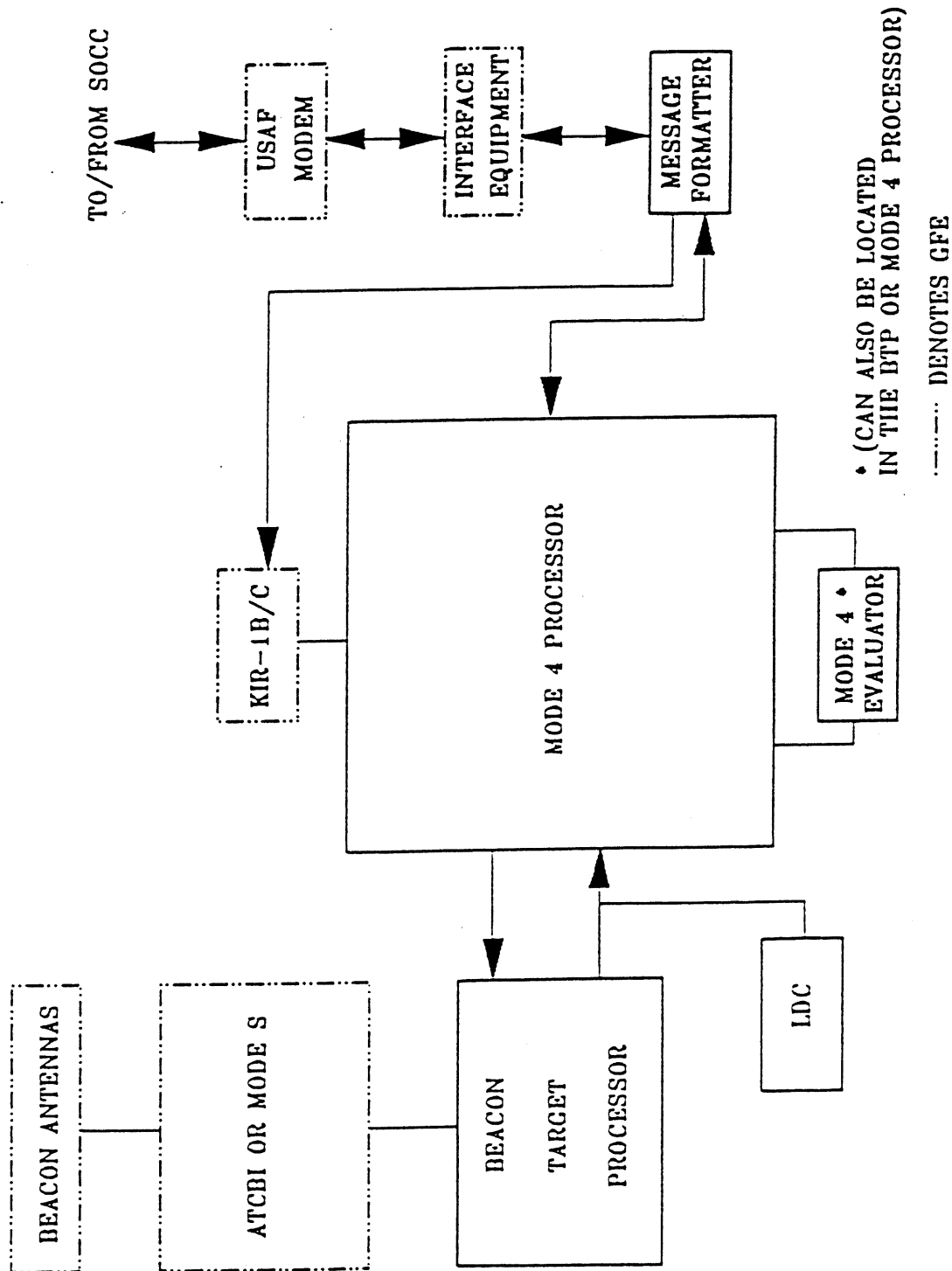
Figure 3-11, INTERFACE DIAGRAM

(a)   The interface between the ATCBI-5 or Mode S Beacon Interrogator
        and the BTP provides the challenge requests, mode selections, and
        enabling signals from the BTP to the ATCBI-5 or Mode S, and also
        the target video signals and timing triggers from the Beacon to
        the BTP.

(b)   The interface between the BTP and the Message Formatter is target
        message information including the Mode 4 message information.

(c)   The interface between the Mode 4 Processor and the BTP provides
        the operational control signals from the SOCC, from the LDC to the
        BTP, and target video signals and timing triggers from the BTP to
        the Mode 4 Processor. Both analog Mode 4 reply video signals and
        Mode 4 time decoded video signals shall be available at this
        interface for display on the LDC and be available at the
        demarcation point.

(d)   The interface between the SOCC and the Mode 4 Processor (via the
        Modem, Interface Device, and formatter) provides the requests for
        operation from the SOCC which are passed along to the BTP with
        "tap-off" signals for the Mode 4 Processor, as appropriate. Also
        included is an alarm signal to the RMS to indicate when the LDC is
        being used.

(e)   The interface between the LDC(s) and the Mode 4 Processor provides
        the same controls for operation as are provided by the SOCC, but
        for operation from the site of the ARSR-4. When the operation is
        controlled by the LDC(s); the controls from the SOCC are inhibited
        at the Mode 4 Processor; and an alarm signal is automatically sent
        back to the SOCC as notification that the control of the ARSR-4 is
        being conducted at the site and SOCC control is not available.

(f)   The interface of the Mode 4 Processor to the Message Formatter
        provides timing triggers to the message formatter. It also
        provides the Mode 4 data to the SOCC via the message formatter,
        KG-84C Interface Device, and Modem.

(g)   The interface between the Message Formatter and the KG-84C
        Interface Device provides all USAF messages for transmission to
        the SOCC.

(h)   The interface between the Formatter and the Mode 4 processor
        provides the Mode 4 request messages from the SOCC.

(i)   The interface between the ARSR-4 system and the EIE provides for
        monitoring of the EIE alarm/status indications.

3.5.20.5 Physical Location of the Mode 4 Subassemblies.- The location of the KIR-1B or KIR-1C requires special attention. The KIR-1B or KIR-1C shall be physically protected (such as with locked mounting) against unauthorized removal, but must be easily removable by authorized personnel. This assembly is not serviced in the field, but is replaced as a standard maintenance procedure. The KG-84Cs will be mounted in fixed plant adapters; the adapters shall be installed in security containers using mounting capabilities provided by the contractor. The fixed plant adapters shall mount into standard 19 inch racks and have a height of 8.75 inches.

(a) The KIR-1B or KIR-1C, the KG-84Cs, and the GRRS or FIRRS shall be secured in NSA-approved security containers (Mosler or Hamilton, Model #54-40 for either company). The internal wiring needed to interconnect the EIE shall be provided by the Government. The contractor shall provide cables for interfacing the formatter with the KIR-1B or KIR-1C and the KG-84Cs. The contractor shall install and interface with sensors on the front and rear doors which shall detect the opening of the doors. An alarm message shall be generated when either or both of the security container doors are opened. The ARSR-4 design shall provide for remoting this container as much as 50 feet away from the rest of the ARSR-4 equipment.

(b) The contractor shall provide a switch panel physically located within the security container having the functions specified in Paragraph 3.5.20.3.

The security container shall house a switch function, accessible only to authorized personnel, which enables/disables the output to the LDC of the friend evaluation data bits, D1 and D2, as specified in Paragraph 3.5.20.3.2.2.1.

Provisions shall be made for mounting the KIR-1B or KIR-1C and the KG-84Cs in the security containers to permit manual rekeying through their key-fill connectors using KYX-15, KYK-13, or KOI-18 fill devices and with the vault door open.

3.5.20.6 Mark XII Operating Controls.- A single control panel shall be provided on the LDC and shall be designed to meet both FAA and Air Force operating requirements. It shall be possible to use multiple paralleled LDCs at the site of the ARSR-4 utilizing a single design of interface cabling.

3.5.20.7 Equipment and Cable Connectors.- The design of all of the Mode 4 hardware (including existing Mark XII equipments) shall be interconnected with Military-Standard cables and connectors. They must mate with existing equipment connectors, including having identical pin locations, to avoid a need for modifying any of the existing hardware. Whenever practical, similar connector types shall be used. The use of adapters to meet these requirements shall not be acceptable.

3.5.21 Remote Monitoring Subsystem (RMS) Interface.- The RMS of the ARSR-4 is part of a total site RMMS that will monitor the overall facility. As such, the radar RMS must interface with a site data concentrator (microprocessor based) which accepts RMS data from all site equipment and concentrates it for transmission to a remote monitoring processor. The concentrator (EIE) will be transparent to the RMS. The concentrator interface requirements are detailed in NAS-MD-790, as modified in paragraph 3.5.15.8.8 of this document.

3.5.22 Modem Interface Requirements.- The ARSR-4 shall be designed to operate correctly and efficiently with the digital data communication equipment without modification to that equipment or its interface requirements specified by FAA-E-2217, Parts 1 and 2. The applicable interface signal characteristics are summarized in the following paragraphs.

The data shall be clocked out of the ARSR-4 by the leading edge of the clock signals generated by independent modem transmitters. The output data shall be valid within 4.5 μsec after the clock's leading (positive-going) edge. The positive amplitude shall represent a logical "1" state.

Although the frequency of the clocks will normally be 2400 Hz (FAA-E-2217, Part 2, paragraph 2-3.3.3 and subparagraphs), the ARSR-4 shall be capable of operating with any clock frequency from 2,400 to 56,000 Hz inclusive, applied to any or all ARSR-4 output data ports. The modem clocks may be synchronous or asynchronous and at different frequencies.

The electrical characteristics of the clock will be as specified in FAA-E-2217, Part 2, paragraph 2-3.2.1.3. The ARSR-4 interface cables and terminations for these clocks shall be such that correct operation is maintained with any combination of conditions permitted by this paragraph of FAA-E-2217, including the 100 Ω source impedance. Five of the 20 output data ports shall have the electrical and mechanical (e.g., 25 pin and 37 pin connectors) characteristics of EIA-RS-232, EIA-RS-422, and EIA-RS-530. Six of the data ports, designated military ports, shall have the electrical and mechanical (25 pin connector) characteristics of EIA-RS-530. The remaining nine of the 20 data ports shall have the electrical and mechanical (25 pin connector) characteristics of EIA-RS-232.

The positive and negative amplitudes shall be balanced to within 10 percent of each other. The positive amplitude shall represent a logical "1" state. The interconnecting cable types for both data and clock shall be compatible with meeting all of the modem interface requirements.

3.5.23 Not Used.-

3.5.24 Automatic Refraction Correction for Radar Height Processing.- The radar height processor shall automatically compensate for the atmospheric refraction in calculating the height of targets. The refraction estimate for the atmosphere between the radar and the targets shall be made from the surface weather data provided by the weather station specified in 3.5.24.1 below. Any reasonably sophisticated atmospheric model can be used for refraction correction and height computation; however, at the minimum, a modified earth radius Ka varying with elevation angle and range, based on the Central Radio Propagation Laboratory model, shall be used. In case of weather station malfunction, the refraction correction factor(s) shall revert to a field adjustable preprogrammed value. The atmospheric model or zero degree elevation Ka value shall be available to the site RMM concentrator for transmission to the MPS on request. The maximum height accuracy error attributed to weather conditions shall be that value corresponding to 30 degrees Celsius at any relative humidity. (The corresponding worst case refractive index (N) for this temperature and humidity shall be 5.5.

3.5.24.1 Weather Station.- The ARSR-4 shall be equipped with weather instruments which will measure local outside air temperature, outside dew point, and local barometric air pressure. These instruments shall be of such design that the information they provide can be digitized for use in the computation of the refraction index (N) of the atmosphere at the approximate elevation of the radar antenna. The processor used to compute the N_S can be housed in an enclosure, or it can be a part of the search data target processor. The digital weather data, including the N_S shall be available at the LDC and to the site's concentrator for transmission to the MPS on request.

3.5.25 Data Extraction Subsystem.- Each ARSR-4 shall include a data extraction subsystem, capable of extracting data from the operating system in real-time, and recording that data for subsequent off-line reduction and analysis. It shall be possible to initiate and operate the data extraction subsystem either locally or remotely, so that data extraction can extract data without on-site personnel, then the data can be retrieved at a later time. The extracted data shall be used as an off-line troubleshooting and analysis tool. Data shall be extractable independently from each of the ARSR-4's Central Processing Units (CPUs) or programmable controllers which processes variable data. The extraction process shall be "fail-soft"; that is, the process shall in no way encumber the capability of the remainder of the ARSR-4. As real-time data processing demand on the ARSR-4 grows to the point where insufficient memory and/or capacity is available for full processing, appropriate indication shall be provided in the extraction data, and the extraction process shall be automatically reduced in extent. As demand on the ARSR-4 diminishes, the extraction process shall resume automatically. The data extraction function shall have the capability to extract all data in any one of the individual categories defined in 3.5.25.1, while at any load up to 100 percent of the capacity load defined in 3.4.1.8 and 3.4.2. The extraction subsystem shall be capable of changing the particular set of data categories extracted in real time, under the control of an operator. It is acceptable for data to be collected in real-time under a generalized format and converted off-line to the formats specified. The Data Extraction Subsystem shall not extract classified data.

3.5.25.1 Data Categories.- The categories for data extraction shall include, but are not limited to, those described below. A complete list of categories for data extraction shall be submitted to the government by the contractor for approval.

(a) All digital I/Os and significant internal data points for the receiver, clutter processing, target extraction, beacon/search reinforcement, scan to scan correlation, formatter, and weather station data functions. Significant internal data points include range bin, azimuth, elevation and other information as necessary to verify the performance of both radar and beacon systems. I and Q data shall only be recorded to the extent possible with site recording equipment.

(b) All digital I/Os and significant internal data points for the weather data subsystem, including the ground clutter suppression, weather averaging and thresholding, and weather data reporting functions.

(c) All digital I/Os and significant internal data points for the BTP.

(d) All digital I/Os for EIE interfaces with the ARSR-4.

(e) RMS data, scan data, and system diagnostics data.

Each block of extracted data shall contain only one category of data and shall have at the start of the block a unique tag to identify the data category within. A minimum of 50 percent of the possible category types shall be left unused by the contractor for future use.

The categories to be extracted shall be selectable. The operator shall have the option of deleting or adding category types after extraction has started without affecting the ones in progress.

It shall be possible to prioritize categories in order to extract preferred data during periods of heavy data load when system limits may cause some data to be lost. There shall be at least four levels of priority. When the condition exists that all desired data cannot be extracted and recorded, the lower priorities shall not be extracted. When the overload conditions clear, the extraction of lower priority data shall automatically be resumed.

The conditions of extraction shall be reported as a header for each category. The header data shall be repeated at selectable intervals from 1 to 60 minutes or when the extraction conditions change.

The contractor shall provide, as a minimum, a complete listing of the various extraction messages, their formats, and proposed data reduction processing. Each type of extraction message shall be identifiable by a unique message code, to facilitate off-line data analysis.

3.5.25.2 Data Reduction.- Data reduction software shall be provided to process the extracted data. It shall be compatible with on-site Quick-Look monitor, on-site printer, and on-site recording equipment and also with use at the ARSR-4 PSF. This software shall provide at least the following functions.

3.5.25.2.1 Quick-Look Data Processing.- Provide at each ARSR-4 site the capability to filter the recorded data for viewing or printing via keyboard commands. As a minimum, category type, scan number, time, beacon code, range cell, azimuth, and altitude shall be included as filter parameters. It shall be possible to group two or more filter parameters using "and", "or", and "if" logic functions to determine which data is viewed and/or printed. There shall be the capability of having multiple filter expressions, each being independent and producing a particular type of data output.

The data output shall be in a form which is easily understandable. It shall be labeled with respect to type and units of the data. The labels shall be present at least once per page and viewing screen and be composed of text, abbreviations, or acronyms.

3.5.25.2.2 Extended Data Processing.- In addition to the "quick-look" data reduction software, the contractor shall provide extended data processing programs which will be used solely at the ARSR-4 PSF. The extended data processing shall include all capabilities specified in 3.5.25.2.1, plus the analysis of ARSR-4 system hardware and software, including all messages. System hardware analyses shall include the capability to determine ARSR-4 range and azimuth resolution from data in beacon and search range and azimuth cells. The ARSR-4 PSF shall have the capability to plot all data provided as a result of the extended analysis. Data shall be plotted with a minimum dot resolution of 1K by 1K, and the hard copy of the plots shall be at least 11 inches by 17 inches.

3.5.25.3 Extraction Equipment.- All hardware and software shall be supplied to record the extracted data and to support the on-site use of data retrieval and quick look analysis data reduction software. The extraction equipment may be a subassembly of the LDC, sharing the LDC keyboard, displays, and printer. The data extraction assembly shall be programmable to record predetermined data samples at selected times and intervals.

If design requirements warrant a stand alone data extraction and analysis assembly, it shall be a general purpose computer conforming to IEEE-796 and shall have the speed and capability to perform the required tasks. It shall have keyboard entry, display, and printing capabilities.

Additionally, a data recording assembly shall be provided and have sufficient storage capability and recording speed to be compatible with the requirements stated in 3.5.16, 3.5.25, and 3.10. This assembly shall have sufficient recording capacity such that target data recorded through the data extraction subsystem for a minimum of two hours of all target data sent to the formatter can be stored on a single unit of magnetic media. The magnetic storage media used to record the extracted data shall be easily transportable.

3.5.26 ARSR-4 Start-Up.-

3.5.26.1 <u>Definition and Purpose</u>.- ARSR-4 start-up is defined as the activity required to bring the ARSR-4 into normal operation after a period of nonoperational status. This function shall provide the capability to bring the ARSR-4 into normal operational "on-line" condition after a period of nonoperational status or equipment configuration change. The function shall be activated by input command from any of the following control units and be performed in an automatic sequence.

(a) ARSR-4 automatic restart (after operational pause) upon command of either the ARSR-4 error recovery or performance monitoring functions (restart after replacement of failed units with standby units or after interruption/restoration of power).

(b) RMMS commands generated at the MPS.

(c) Local commands generated by on-site personnel.

3.5.26.2 <u>Initalization of System</u>.- Bringing the ARSR-4 system up from a nonoperational status shall include time of year clock synchronization and site operational program loading. Without any data modifications, the ARSR-4, excluding the LDC, shall come to its full operational configuration within one hundred eighty (180) seconds.

3.5.26.3 <u>System Recovery</u>.- The ARSR-4 shall meet the requirements of 3.6 in the event of partial or complete loss of line voltages.

3.5.26.4 <u>Computer Software Loading</u>.- Operational computer program software loading, excluding the operating system, shall be from EEPROMs into RAM for ARSR-4 operation. The ARSR-4 shall also have the capability to load the master software into EEPROMs from transportable mass storage media, in addition to any other program installation technique provided by the contractor.

3.5.27 <u>Site Operational Software</u>.- The contractor shall provide all software required for the operation of the ARSR-4 in accordance with the terms of this specification. The operational software shall provide the capability to adapt each site to local conditions and site specific operational requirements. Selection of adaptation parameters shall be based upon the requirements listed in this specification. These parameters shall include, but not be limited to, the major type categories listed below.

(a) Operating parameters of associated site equipment interconnecting to the ARSR-4.

(b) ARSR-4 system calibration data.

(c) Geographical data (e.g., site specific radar coverage data, map parameters, and site elevation).

(d) ARSR-4 RMS calibration performance monitor parameters (e.g., alarm decision tables, RMM data reporting criteria.)

(e) ARSR-4 operational parameters to be used.

(f) Control of ARSR-4 logical functional units.

(g) Other ARSR-4 functional parameter values that may be affected by special conditions occurring at a particular site and, hence, requiring other than the normal parameter values.

The design of the software shall allow site adaptation parameters to be entered into ARSR-4 nonvolatile memory in two ways, from a manual keyboard and from transportable mass storage media. Each entry shall occupy only one memory location. Entry of site adaptation data shall be performed with minimum ARSR-4 downtime (only the time required to load the new program data).

3.5.27.1 ARSR-4 Site/Field Adjustable Parameters.- The operational software shall provide for the entry or change of parameters identified as either site adjustable or field adjustable in this specification with no downtime. Field adjustable parameters shall be entered or changed from either remotely located consoles through the RMMS or from the site using the LDC and the portable terminal (EIE). The control of the site adjustable parameters shall only be performed at each ARSR-4 site. The following capabilities shall be available for use by on-site maintenance personnel.

(a) Installation of the master functional program from a transportable mass storage media into ARSR-4 nonvolatile memory.

(b) Installation of the ARSR-4 site/field adjustable parameters into nonvolatile memory. These parameters shall be entered manually or from transportable mass storage media at the site.

(c) Stc.ing the ARSR-4 system operational program in RAM that has access to the ARSR-4 site adjustable, field adjustable, and site adaptation parameters stored in nonvolatile memory.

(d) Selection of any of the ARSR-4 site adjustable parameters by on-site maintenance personnel for either temporary or permanent changes.

3.6 Primary Power Requirements.- The equipment shall normally operate from a commercial prime power source of three phase, four wire AC, line. The design center voltages shall be 60 Hz, 208 V, Phase-to-Phase and 120 V Phase-to-Neutral with a maximum voltage range allowance ± 15 percent. The total harmonic content of the input current caused by the system/equipment and fed back onto an AC supply system shall not exceed six percent of the fundamental (60 Hz), and no single harmonic shall be greater than three and one-half percent of the fundamental. In case of failure of the prime power source, power from an auxiliary engine-generator source (not a part of this specification) will be automatically connected to furnish power to the equipment within 15 seconds. Prior to switching to auxiliary power, the remnants of commercial power (e.g., two phases remain connected and one phase is lost) normally remain connected to the radar system. The ARSR-4 shall be designed in such a manner so that the remnants of commercial power not damage the equipment or in any way affect the capability of the ARSR-4 to recover following restoration of primary power. Prime power requirements of the ARSR-4, which includes all items provided by the contractor, shall be limited to 65 KVA. Beacon equipment (ATCBI-5 or Mode S) shall be excluded from the load calculation

3.6.1 Prevention of Data Loss.- The contractor shall provide the means for maintaining any critical data necessary to restore the system to normal operation within 100 msec following restoration of power when primary power failure occurs for greater than 20 msec, but equal to or less than 15 seconds. The antenna may take up to 10 seconds to return to normal operation (e.g. 12 second scan rate) after a momentary, less than 15 seconds, power outage. The transmitter may take up to 3 seconds to return to normal operation (e.g. RF up) after a momentary, less than 15 seconds, power outage. The restoration of normal operation shall be automatic. All operational programs, fixed and dynamic map(s), field and site adjustable/selectable parameter settings shall be preserved. Data in the scan to scan correlation function shall be preserved and track continuity maintained.

For power variations outside the voltage range specified in Table IV of FAA-G2100, the following modifies paragraph 3.3.4.1 of FAA-G-2100. The transmitter is not required to radiate; however, upon re-application of normal line voltage, the transmitter will resume full normal operation. Additionally, the radar system will resume normal operation without loss of critical radar timing, APG data, range/azimuth gating data, operational programs, fixed or dynamic map(s), and field and site adjustable/selectable parameter settings.

For power interruptions in excess of 15 seconds, the ARSR-4 system operation shall be automatically restored within three minutes after power is restored. Fixed map(s) and field and site adjustable/selectable parameter settings shall be preserved.

3.6.1.1 Power Variations.- The ARSR-4 and all supporting equipment shall meet all functional and performance requirements, and shall not output any such false data during operation under the environmental conditions listed in Table II of FAA-G-2100. The following items amend Table II of FAA-G-2100.

(a) Over slowly varying AC line voltage within specified limits, changing at the rate of 5.0 V/sec or less.

(b) Over slowly varying AC line frequency within specified limits, changing at the rate of 1.0 Hz/sec or less.

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(c)   The ARSR-4 equipment shall operate correctly with no shutdown in the presence of partial or complete loss of the line voltage(s) for up to 20 msec at a time.

(d)   No damage shall occur to the ARSR-4 due to partial or complete loss of line voltage.

3.6.1.2 Transient Protection.- The contractor shall provide transient protection for ARSR-4 power supplies and their loads, without resorting to power conditioning equipment. Transient protection shall be sufficient to deal with transients from either commercially generated power or from on-site emergency generated power. The type of transient protection used shall consist of, but not be limited to: voltage transient protection on input power lines; in-rush limiting circuits in power supplies to prevent damage to rectifiers during turn-on; and soft restarts that allow power supply loads to be turned on in sequence during the start-up cycle specified in 3.5.26.

In addition to transient protection, power supply reliability shall be increased by conforming to the guidelines established in NAVMAT P4855-1. Reliability of power supply loads shall be increased by automatically isolating sensitive circuits from detected power line anomalies. Anomalies such as ground loops in the loads shall be automatically detected and isolated to improve personnel safety.

3.6.1.3 Power Consumption.- The contractor shall provide the Government with information as to the normal operating and peak power loads of the ARSR-4. Data furnished shall describe the following conditions:

(a)   Normal operation; i.e., 24 hours a day, unattended.

(b)   Attended/maintenance operation; all equipment in maintenance mode, worst case combination of day/night and summer/winter conditions.

Power consumption data shall be furnished for each assembly or cabinet of the ARSR-4 (transmitter, antenna, receiver, processor, RMS, etc.) for the above conditions. The contractor shall design the ARSR-4 in order to minimize power consumption during all load conditions, particularly under the normal operating load conditions.

3.6.1.4 Input AC Line Controls.- Except as otherwise permitted each ARSR-4 subsystem shall have its own power supplies and associated controls for the input AC power lines. In addition, a master power control for each ARSR-4 cabinet [antenna and Transmit/Receive (TR) subsystem] and an ARSR-4 main power control shall be provided. All controls shall meet the requirements of FAA-G-2100 paragraph 3.3.2.1. The power on-off controls for each subsystem shall be circuit breakers meeting the requirements in 3.3.2.1.5 of FAA-G-2100. Fuses shall not be allowed as protective devices for any subsystem. A tripped or manually turned-off breaker on any subsystem shall initiate a conspicuous display of that condition. It shall not be possible for a subsystem to be

without power, without an indication of that condition appearing on a status and alarm panel, and initiating an alarm.

3.7 Data Processor Architecture.- The data processor subsystem shall be composed of several microprocessors tied to a multiple bus. The contractor shall design the ARSR-4 hardware and software in the target processing subsystem so that an architecture of prime shadowing of multiple microprocessors is employed. If a microprocessor or several microprocessors in this subsystem fail for more than 100 msec, the other microprocessors shall automatically, and without a loss of data, assume the tasks of the failed microprocessor(s). Additionally, this data processor subsystem shall monitor the RMS processing and shall assume the role of the RMS processor in the event of a RMS microprocessor failure.

3.8 Physical and Electrical Characteristics.- The requirements specified in subparagraphs hereunder apply on all items in the contract unless otherwise noted, and are in addition to specific equipment requirements contained herein or in other referenced specifications.

3.8.1 Packaging and Construction.- The basic packaging concept of the equipment shall be plug-in LRUs mounted in standard cabinets (3.8.1.4), to the extent practicable. The structural strength and rigidity of equipment assemblies and cabinets shall be such that normal handling in loading, shipping, unloading, and setting into position for installation shall not damage the equipment. At least 20 percent of the front panel of each equipment cabinet, together with the interior cabinet space behind it, shall be left unused. Blank panels shall be furnished and installed for any unused space. The weight of each module, LRU, and printed circuit board/card shall not exceed 35 pounds, unless otherwise approved by the Government, as specified in MIL-STD-1472.

3.8.1.1 Use of Existing Towers.- The ARSR-4 shall be of such size, weight, and cubic dimensions as to permit installation and operation, together with the GFE beacon antennas, on existing towers and in CFE radomes. Any modification to the existing towers required to install the radomes shall be provided by the Government.

3.8.1.2 Modules.- All equipment designs shall use modular construction with the number of unique modules kept to a minimum. Plug-in modules shall be standardized to permit interchangeability of like modules without alignment or adjustment. All modules shall be keyed to prevent incorrect installation.

3.8.1.2.1 Modular Concept.- The configuration of the modular assemblies shall be one of the following:

(a) Standard rack mounting slide-out drawers or chassis. Drawer slides shall be heavy-duty locking type to permit locking the drawer or chassis in either the normal (closed) or extended position. LRUs shall be mounted vertically in the drawers/chassis.

(b) Standard rack mounting assemblies with shelf mounted LRUs that plug into a front panel/chassis assembly. LRUs shall be mounted vertically.

(c) Standard rack mounting assemblies with swing-out shelves or card cages with vertical or horizontal hinges. LRUs shall be mounted vertically with the equipment in its normal operating configuration.

3.8.1.2.2 Plug-in LRUs.- Plug-in LRUs shall be designed for mounting in card bins or module bins. Plug-in LRUs shall have a metal chassis or other suitable framework to provide a solid part mounting structure, with adequate protection for printed wiring and small parts when inserting, removing, or during handling of LRUs after removal from the equipment. All plug-in LRUs shall be capable of casual removal and insertion with power ON and without damage to any circuitry.

3.8.1.2.2.1 LRU Removal and Insertion Damage.- All equipment shall be designed to enable the casual removal and insertion of LRUs without causing or inducing damage to any equipment external to the LRU.

3.8.1.2.2.2 Induced Transients.- A means shall be provided to enable the removal or insertion of all LRUs, while on-line, without generating any logic or electronic disturbance that may affect the on-line system operation.

3.8.1.2.3 LRU Card Extenders.- For each ARSR-4 provided, a LRU card "extender" shall be supplied for each type of LRU. An extender consists of a printed circuit board (not keyed in order to permit insertion into any connector) with printed circuitry and coaxial leads. This extender shall extend all input points across the LRU to a receptacle on the opposite end. The removed assembly can then be plugged into the opposite end of the extender. The extender thus provides an accessible active operating position for any assembly normally inaccessible for maintenance and test while within the bin. Provisions shall be included to prevent an LRU from being improperly oriented (for example, a printed circuit card reversed) when the extender is in use. No permanent degradation of system, subsystem, or LRU performance shall result from proper use of the extenders. The contractor shall identify to the Government any LRU, such as high speed digital circuits, that will not perform properly while on extenders.

3.8.1.2.4 Mounting.- Plug-in LRUs shall be mounted side-by-side, bookcase style, in an assembly, and shall be equipped with chassis guide strips or rails (or both) and mating connectors, as are necessary to ensure positive alignment of the LRU connector with its mating receptacle. Quick acting fasteners shall securely lock front-panel type plug-in LRUs in their operating position. A maximum withdrawal force of less than ten pounds shall be required to remove any LRU.

3.8.1.2.5 Connectors.- The connectors' receptacles shall contain a polarizing key. The key location shall be different for each unique configuration of LRU. All assemblies of the same type shall have the same polarizing key location to ensure the proper type of LRU is inserted. The keying method shall not reduce the number of connector pins. Mating connectors shall be designed for repeated use with the LRUs to ensure long-term reliable performance and with suitable mountings to permit casual insertion without jamming or otherwise damaging the connector units.

3.8.1.2.6 Interlocks.- Each LRU shall be provided with one or more interlocks which removes all voltages of 150 V or higher upon the opening of the LRU for maintenance or adjustment of internal controls. The interlocks shall have a manual bypass which can be activated to prevent interruption of these voltages when the LRU is opened. The interlocks shall meet the requirements of paragraph 3.3.7.1.6 of FAA-G-2100.

3.8.1.3 Design and Construction.- The ARSR-4 shall be designed and constructed to comply with the electrical and mechanical design requirements specified in the following subparagraphs. All LRUs of a given type shall be identical and interchangeable.

3.8.1.3.1 Corrosion Control.- Corrosion control shall comply with the requirements of MIL-STD-1250.

3.8.1.3.2 Materials and Finishes.- The requirements of FAA-G-2100, paragraphs 3.6 and 3.7.6 govern the selection of materials and finishes with the exception that chemical film treatment of the surfaces of aluminum and aluminum alloy (except castings) shall be equivalent to Class IA or Class 3 of MIL-C-5541 or clear anodizing. Departures from any of the aforementioned requirements requires Government approval.

3.8.1.3.3 Equipment Surfaces Painting.- All ARSR-4 equipment surfaces shall be treated and painted in accordance with FAA-STD-012, unless performance requirements herein or evironmental regulations can not be achieved with the surface treatment of FAA-STD-012. Then specific written approval shall be obtained from the Government waiving this painting requirement. The color selection of the equipment surfaces in and on the tower and radome shall be selected by the contractor and approved by the Government. The color of the radome shall meet the requirements of 3.5.1.2.1.6. The color of the equipment inside the ARSR-4 equipment room shall meet the requirements of 3.8.1.3.2. Departures from any of the aforementioned requirements requires Government approval.

3.8.1.4 Cabinet Design.- Equipment cabinets shall be of uniform size, not to exceed 80 inches in height and 30 inches in depth and 36 inches in width. All cabinets shall be of high quality, sturdy construction, accurately and carefully fabricated, and with facilities for leveling (or shimming) and fastening to the floor. Ventilation air shall enter near the bottom and exit from the cabinet top, with the air exit screened or otherwise protected to prevent small objects from falling into the cabinet. This exit shall be suitable for connection to a duct for venting. Cables may be routed directly through the interconnecting walls by means of appropriate feed-throughs and/or connectors. Access to the cabinet interior for normal maintenance shall be from the front only, with full width latching access doors extending from near the top of the cabinet down to the air inlet. Rear access is permitted only for the purpose of installation, replacement, or repair of interconnecting cables or wires. Access doors shall be mounted by slip-pin hinges so that the doors may be easily removed. The hinges shall be adjustable and secured to the cabinets by means of screws and nuts and bolts. All cable and waveguide shall enter the cabinets near the top. Panels, chassis and LRU bins shall be adequately supported within the cabinets and be of a size and weight that shall permit removal and replacement by one technician. Convenience outlets (as per paragraph 3.3.2.1.7 of FAA-G-2100) shall be provided on the lower front of each cabinet.

3.8.1.4.1 Overheat Warning Devices.- As a minimum, each cabinet shall be provided with a temperature sensor located just inside the air exhaust outlet. Sensing of a temperature rise in excess of the design limit shall be indicated by a warning light conspicuously located on the cabinet, as well as by a subsystem fault light. Additional temperature sensors and air flow switches shall be provided as necessary to protect the subsystem from damage. The cabinet overtemperature indication shall be fed to the RMS.

3.8.1.4.2 Cabinet Illumination.- Shielded lights for general illumination of the cabinet interiors shall be provided. These lights shall be turned on by opening of the cabinet access door and turned off by closing the door. With the door open, manual control of the lights shall also be possible. If meters, controls, test points, etc., are visible or accessible with the access doors closed, additional lighting shall be provided as is required to make them readily visible with the room lights turned off. Manual control of these lights shall be provided.

3.8.1.4.3 Front Panel Connectors and Cables.- Front panel connectors and cables shall be limited to those required for testing.

3.8.1.4.4 Shorting Rods.- Adequately insulated shorting rods with a connecting grounding strap permanently affixed to good cabinet grounds shall be provided and installed on hooks inside the doors of all cabinets which contain voltages (other than primary AC power) in excess of 150 V to enable maintenance personnel to ground all points which are potentially hazardous before performing equipment maintenance. Caution plates shall be installed in appropriate locations to remind maintenance personnel to utilize the shorting rods before performing any maintenance on the equipment.

3.8.1.4.5 Large Units.- If applicable, large units may be mounted on a horizontal chassis, mounted horizontally at floor level such that fasteners, terminals, and associated wiring for such units are easily accessible for maintenance testing and repair through the front access door without requiring removal of the chassis.

3.8.1.4.6 Indicator Lights.- The contractor shall provide indicator lights in accordance with MIL-STD-1472 at the LDC and at the cabinets associated with each ARSR-4 function to indicate the status of each selectable function, the redundant units that are in use, and the units that are in a failed state.

3.8.1.5 Ventilation, Heating, and Cooling Equipment.- All blowers, vents, and other environmental controlling equipment necessary for the operation of the equipment over the range of the service conditions shall be provided by the contractor. The ARSR-4 equipment shall not be dependent on building/room air conditioning which may or may not exist. Each cabinet, including radar transmitter cabinets that may be located in the equipment room, shall contain its own blower subsystem. The contractor shall conduct a study of the ARSR-4 ventilation, heating and cooling needs which meets the requirements of 3.4.6 herein and FAA-G-2100, and submit a proposed list of requirements, on a site by site basis, for Government approval. Outside air, if used, shall be filtered (e.g., protective devices for ducts/vents such as louvers or screens or both) to prevent water, insects, and other contaminants from entering the ductwork and building. The equipment shall not overheat, develop hot spots, or become unstable in operation with access doors of any or all cabinets open or closed for up to 8 hours.

3.8.1.5.1 Ventilation Blowers.- All primary cabinet blowers shall be three phase, continuous duty type. Auxiliary blower motors as, for example, might be employed for moving air directly through the heat sink of a power supply, may be single phase provided, however, that they do not exceed 0.1 horsepower in capacity. All blower motors shall be equipped with sealed, permanently lubricated bearings.

3.8.1.5.2 Air Filters.- Disposable air filters shall be used and shall be in accordance with paragraph 3.3.3.5.1 of FAA-G-2100. The air filters shall be removable from the outside (exterior) of the equipment cabinets without the necessity of opening access doors or moving any other equipment cabinets.

3.8.1.6 Not Used.-

3.8.1.7 Safety.- System equipments shall be designed and constructed so that the potential for personal injury during installation, operation, and maintenance is minimized. The provisions of FAA-G-2100, paragraph 3.3.7 apply.

Control of modular construction shall be such that operator/maintenance personnel cannot induce failure of the equipment. Malfunctions in the equipment shall not induce any other failure into any CFE or EIE.

3.8.1.7.1 Electromagnetic Radiation (EMR).- Electromagnetic radiation shall not exceed the permissible exposure limits specified in FAA-Order 3910.3.

3.8.1.8 Human Performance/Human Engineering.- The systems' equipment design shall conform to human engineering design criteria and principles to achieve safe, reliable, and effective performance by operator and maintenance personnel and to minimize personnel skill requirements and training time. The human engineering shall be in accordance with MIL-H-46855.

Noise levels limits shall be as specified in paragraph 3.3.1.3.2 of FAA-G-2100 with the values of Table I, FAA-G-2100, modified as follows:

NOISE LEVEL LIMITS

Frequency Bands (Hz)	Noise Limits (dB)
20-150	89
150-300	82
300-600	76
600-1200	73
1200-2400	70
2400-4800	68
4800-20000	66

The noise level limits shall apply to the simultaneous operation of all equipment, including the I/O devices.

3.8.1.8.1 Access for Maintenance.- All ARSR-4 equipments shall be configured so as to provide ready access for replacement at the LRU level. The accessibility requirements of FAA-G-2100 shall be met.

3.8.1.9 Workmanship.- Workmanship shall comply with the requirements of MIL-STD-454, Requirement 9.

3.8.1.10 Interchangeability.- Interchangeability shall be governed by the provisions of MIL-STD-454, Requirement 7.

3.8.1.11 Nameplates and Product Marking.- Nameplates and product marking shall be in accordance with FAA-G-2100. Each major chassis shall have a name plate and be located in such a manner as to meet Government approval.

3.8.1.12 Test Points.- Test points and facilities for connecting test equipment shall be provided for determining the performance quality of the equipment. Test points shall be in accordance with FAA-G-2100, paragraph 3.3.2.4.

The contractor shall standardize all LRU, unit, and circuit card assembly designs to conform with MIL-STD-2076(AS) requirements. For the purpose of this specification, the term "weapon replaceable assembly" used in MIL-STD-2076(AS) is equivalent to an LRU.

3.8.1.13 Wire Identification.- Wire color coding shall conform to FAA-G-2100, paragraph 3.5.5.25.11, except color coding is not required for wires used in backplane wiring.

3.8.1.14 Printed Circuit Cards.- Printed wiring circuit cards are boards utilizing printed wiring techniques and containing positions to plug-in or solder-in integrated circuits or discrete units. Printed wiring circuit card assemblies shall be considered the same as printed wiring boards, printed circuit cards, circuit card assemblies, and printed wiring assemblies. Single sided, double sided, and multilayer printed circuit cards shall conform to the requirements of FAA-G-2100, paragraph 3.5.5.15, unless technical justification is provided to the Government for approval via contract letter. Screwdriver adjustments required for alignment shall be held to a minimum; however, when required, such adjustments shall be made on the printed circuit card. All printed circuit cards shall use a common position on the connectors for the power supply and ground leads. Printed circuit cards using wire wrap pins shall have a pin guard/stiffener around at least three sides. All printed circuit cards equipped with integrated circuit sockets and larger than 5 by 7 inches shall have a stiffener around at least three sides. Any departure from this requirement calls for technical justification for Government approval via contract letter. The maximum size of any printed circuit card shall be 12.0 by 16.0 inches except where ARSR-4 performance would be degraded by use of this size card. The contractor shall provide technical support data describing the adverse impact of using the 12.0 by 16.0 inch card with a request for the use of a larger card. Regardless of the larger printed circuit card size, the printed circuit card shall still be compatible with the automatic test equipment provided with the ARSR-4.

Conformal coating of circuit cards shall not be used in the ARSR-4 design. Some of the documents invoked through this specification for circuit cards are predicated on the use of conformal coating. The requirements of those documents shall still apply to the ARSR-4 design, except that the conformal coating shall not be applied. The minimum spacing requirements between conductors, conductor patterns, and conductive materials (such as conductive markings or mounting hardware) of MIL-STD-275 and MIL-P-28809 shall be modified as follows:

Voltage Between Conductors	Minimum Spacing
0 to 10 volts, DC or AC peak	0.015 inch
11 to 75 volts, DC or AC peak	0.020 inch
76 to 150 volts, DC or AC peak	0.025 inch
151 to 300 volts, DC or AC peak	0.050 inch
301 to 500 volts, DC or AC peak	0.100 inch
Greater than 500 volts, DC or AC peak	0.0002 inch/volt

Rework, repair, and/or modification of any printed wiring circuit card assembly shall be permitted only with specific written authorization of the ARSR-4 contracting officer. Rework, repair, and/or modification of circuit card assemblies shall be in accordance with the requirements of MIL-P-28809 with the exception that the combined total number of jumper wires, including the design, rework, repairs, and/or modifications, shall not exceed a maximum of three. Any departure from this requirement calls for technical justification for Government approval via contract letter. The contractor shall provide all required changes to the technical and provisioning documentation, test and diagnostic support tools, adapters, provisioning, and logistics data that are needed as a result of any board modifications. All rework, repair, or modification of circuit card assemblies shall not degrade any of the performance requirements specified in 3.4.3, 3.4.4, and MIL-STD-275.

Any circuit card assembly with modifications and/or repairs used in the ARSR-4 prior to Government acceptance of system 15, shall be replaced by the contractor with a new circuit card assembly incorporating all changes (including the deletion of all jumper wires) to the conductor pattern, drilled features, or other characteristics. System 16 and subsequent systems delivered to the field site shall have the new circuit cards incorporated before delivery. The first 15 articles delivered shall be retrofitted by the contractor with new circuit cards. All spares inventory shall be updated by the contractor with the new circuit cards.

3.8.1.14.1 Circuit Card Assemblies.- Circuit card assemblies are printed circuit cards populated by discrete units or integrated circuits. Circuit card assemblies used for digital logic integrated circuits shall incorporate dual-in-line packages. The individual integrated circuits (including PROMs, microprocessors, etc.) shall be able to be removed intact and replaced by average technical field personnel in less than 90 seconds using common tools or special tools provided with the ARSR-4. A minimum of ten removal and replacement cycles at a given integrated circuit location shall be able to be performed in this manner at up to ten integrated circuit locations on up to 50 circuit card assemblies without causing failure of the circuit card assembly or a degradation of the ARSR-4's reliability below the requirements of 3.4.3 herein.

Circuit card assemblies containing discrete semiconductors, linear integrated circuits and their supporting units shall be able to have their active devices removed and replaced in accordance with these same requirements, except that the removal-replacement time is changed to less than five minutes.

All circuit card assemblies shall be able to be tested with Automatic Test Equipment (ATE) and repaired when any unit thereon fails, for the full service life of the ARSR-4 in its normal operating and maintenance environment.

The minimum number of circuit card assembly types, necessary to implement the requirements of this specification, shall be utilized. All circuit card assemblies shall be able to be inserted and removed with power applied to the circuit card assembly without causing oscillations or damage to any units and without requiring removal and reapplication of power to re-initialize the operation. Power supply shut-off prior to circuit card assembly removal and reinsertion shall be permitted in those areas where automatic redundancy exists and where power shut-off does not affect ARSR-4 operation.

3.8.1.14.2 Unit Mounting.- All semiconductor and integrated circuit units shall be mounted as specified in FAA-G-2100 unless other mounting techniques (e.g. sockets) are necessary to meet other requirements herein. In the event that such deviation is necessary, the contractor shall obtain the approval of the Contracting Officer by submitting the appropriate technical justification, including the changes, if any, to the calculated reliability and service life of the equipment. All electronic parts shall be attached such that each part is amenable to removal and replacement without damage to the circuit card assembly.

3.8.1.14.3 Circuit Card Assembly Modification.- To enhance the ability of the circuit card assemblies in the ARSR-4 and its supporting equipment to meet future requirements, all circuit card assemblies shall be able to be easily modified to alter their original functions, logic operations, or unit interconnections. In order to provide the required alterability, circuit card assemblies consisting entirely of integrated circuits and their necessary passive supporting units such as capacitors, diodes, etc., shall use discrete point-to-point wiring on the opposite side of the circuit card assembly from the integrated circuit chips, unless the contractor has received specific written approval from the Contracting Officer for deviations from this requirement. Approval will be granted only upon technical justification to the Government that the required ability to alter the circuit card circuitry or functions can be accomplished by means satisfactory to the Government (e.g. reprogramming of microprocessors), or that a specific board is a standard type already in existence (e.g., industry microprocessor bus standards for RMM use or processors previously designed for other FAA equipment). Multilayer printed wiring or similar techniques which produce inaccessible unit interconnections may be used for this type of circuit card assembly only with specific approval of the Government.

All other types of circuit card assemblies, including all assemblies that provide interface signals to or from equipment external to the ARSR-4 or its supporting equipment, shall utilize discrete point-to-point wiring. Alternatively, printed wiring techniques in which all interunit connections are accessible may be used for these circuit card assemblies. Both sides of the board may be used for such printed wiring, provided that the accessibility requirement is met.

Wrapped circuit connections meeting the requirements of 3.8.1.14.5 or multi-layer soldered wiring may be used as discrete point-to-point wiring. Regardless of which of these two approaches is chosen; its strength, reliability, wear resistance, and modification characteristics shall be satisfactorily demonstrated to, and approved by, the Government before it is used in production equipment.

3.8.1.14.4 Printed Circuit Card Baseboard.- Printed circuit cards shall be sufficiently rigid to prevent damage to any conductive patterns during manufacture and subsequent handling and, if integrated circuit sockets are used, to prevent integrated circuits from loosening in the sockets when boards are flexed.

All printed circuit cards shall provide a convenient and positive means of removal from, and insertion into, a card bin without the use of a separate tool. Handles, finger holds, or similar means may be used. The selected technique shall permit easy removal and insertion without damage or undue strain on card bin frames, the units and wiring on the printed circuit card, or the connectors on the printed circuit card or card-bin. The maximum insertion or extraction force for any printed circuit card or other plug-in assembly shall be less than ten pounds.

All printed circuit cards shall conform to the applicable paragraphs of FAA-G-2100, unless technical justification is provided to the Government for approval via contract letter. One-part connectors and base boards meeting the requirements of MIL-STD-275 are permitted.

3.8.1.14.5 Solderless Wrapped Electrical Connections.- Solderless wrapped electrical connections may be used with appropriately designed wraposts (terminals). Solderless wrapped electrical connections shall be in accordance with MIL-STD-1130. Copper conductors shall be annealed, oxygen-free high conductivity solid copper wire as defined in ASTM-B224.

3.8.1.14.6 Printed Circuit Card Connectors.- The number of pins on a printed circuit card shall be 310 or less, not including test points. Additionally, at least 20 percent spare pins shall be provided. The connector receptacles and the printed circuit card connectors shall be polarized and keyed such that the printed circuit cards can be inserted with the correct sense only and that the proper type of printed circuit card can be inserted in a given location. The keying method shall not affect the number of pins on a connector. In the event that polarizing keys are used, they shall not be able to be removed during normal insert-remove operations. The particular edge-board (one-part) connector to be used shall conform to an American standard. DIN type connectors shall not be used. Mating connectors shall be designed for repeated use and long term reliable performance without jamming or damage as a result of frequent casual insertion of printed circuit cards. At least 100 casual (as contrasted with "careful") insertion and removal cycles of the printed circuit cards shall be possible without damage, degraded operation, or reduced reliability.

3.8.1.14.7 Circuit Card Assembly Test Points.- Sufficient test points and connectors shall be provided on all circuit card assemblies to meet the automatic diagnostic requirements for the ATE recommended per the SOW. Test points used for critical on-line measurements shall be easily accessible without the use of card extenders so as not to interrupt the search data flow during preventive maintenance inspections.

3.8.1.15 Controls.- All circuits shall be so designed that no damage results from the equipment being operated with the operating controls and maintenance adjustments set to any possible combination of settings. No circuit breakers shall trip as a result of actuation of any operational controls. There shall be no noticeable lag between the actuation or adjustment of controls and the effect of the actuation or adjustment. All controls shall have calibrated markings to permit setting to predetermined positions, except where it can be demonstrated to the satisfaction of the Government that this is impractical or unnecessary. Maintenance adjustment controls shall employ small knurled knobs. Where the special nature of a function makes a large knob or screwdriver slot desirable, the use of such controls shall be subject to specific Government approval. Motor driven switches and controls are prohibited except for waveguide switches, motor-driven auto transformers, and antenna polarization controls (if applicable).

3.8.1.15.1 Location of Controls.- All frequently used controls on plug-in LRUs shall be accessible without removal of the LRU from its normal position. Controls on units using vertical panel construction shall be on the front surface of the panel of the unit with which the control is associated. Controls for horizontal chassis units shall be mounted on front panels or immediately behind front access panel doors of each unit. All controls shall be mounted so as to minimize the possibility of personnel coming in contact with high voltages or units operating at high temperature, or both and shall be in conformance with FAA-G-2100, paragraph 3.5.6.2. Wirestraps and plug-in jumpers are prohibited as a means of control. Dual In-line Package (DIP) switches and suitable rotary controls shall be used. All controls on LRUs must be accessible without placing the LRU on an extender card or otherwise disrupting operations.

3.8.1.16 Unit Requirements.-

3.8.1.16.1 Semiconductors.- Military standard semiconductors shall be selected in accordance with paragraph 3.5.5.20 of FAA-G-2100. All non-JAN devices shall be screened in accordance with Table II of MIL-S-19500. All device types shall be tested to the Group A, Table III AND Group B, Table IV quality conformance requirements of MIL-S-19500, as a minimum. The following device restrictions apply:

(a) Only solid glass metallurgically bonded axial lead diodes and rectifiers shall be used, except in the case of ceramic sealed, chip PIN diodes operating at microwave frequencies.

(b) TO-5 packages shall be limited to the solid metal header type.

(c) All semiconductor device junctions must be protected, and no organic or desiccant materials shall be included in the package.

(d) Devices using aluminum wire shall not use thermocompression wedge bonding.

(e) Aluminum TO-3 packages shall not be used.

(f) Germanium devices shall not be used.

(g) Power semiconductors shall be derated per AFSC Pamphlet 800-27.

3.8.1.16.1.1 Semiconductor Terminal Identification.- All discrete transistors mounted on LRUs shall have a character "C," representing the collector, on the wiring side of the circuit board in a location approximating the collector terminal. In the case of field-effect semiconductors, the character "D," representing the drain, shall be used.

3.8.1.16.2 Microcircuits.- Microcircuits shall be selected in accordance with FAA-G-2100, paragraph 3.5.5.13. All non-JAN devices shall be tested in accordance with the Class B screening requirements of MIL-STD-883, Method 5004 and 5008, as applicable. All device types shall be tested to the quality conformance requirements of MIL-STD-883, Method 5005 and 5008, Class B.

3.8.1.16.2.1 Integrated Circuits.- In addition to meeting Requirement 64 of MIL-STD-454, Integrated Circuits shall be derated per AFSC Pamphlet 800-27.

3.8.1.16.2.2 Sockets for Microelectronic Devices.- All semiconductor and integrated circuit units shall be mounted as specified in FAA-G-2100, except that other mounting techniques (e.g., sockets as specified in paragraph 3.5.5.21.1 of FAA-G-2100) will be permitted in association with wirewrapped integrated circuit assemblies. In the event such deviation is necessary, the contractor shall obtain specific Government approval for the mounting technique and/or sockets with reliability data to support such use.

3.8.1.16.3 Critical Parts.- Hybrid (including radio frequency, microwave, and millimeter type) and complex monolithic microcircuits shall be considered critical parts as defined under "Reliability Critical Items" in MIL-STD-785.

3.8.1.16.4 Nonaxial-Leaded Parts.- Nonaxial-leaded parts (excluding transistors and integrated circuits) shall be mounted against or as close as possible to the LRU.

3.8.1.16.5 Relays.- Relays shall require Government approval using a Request for Nonstandard Parts and shall conform to the requirements of FAA-G-2100. In addition to the requirements of FAA-G-2100, relays utilized in the system shall meet the following requirement. A circuit diagram shall be provided on each relay. All chassis-mounted relays shall be of the plug-in type. The number of different relay types used shall be held to an absolute minimum. Each DC relay coil shall have a suitable damping diode or other device to eliminate transients.

3.8.1.16.6 Transformers.- A three phase power transformer may be used where isolation of the three phase power line is required for use within the transmitter cabinet. This transformer shall meet the requirements of MIL-T-21038, Class R, Life Expectancy X; but shall be excluded from meeting sealing, immersion, vibration, and shock requirements of Grade 4 units. Material used in construction of the transformer shall meet the design requirements of MIL-T-27, Grade 4; however, air cooled open winding construction may be used provided that the transformer is located physically within the transmitter cabinet and a metal protective cover is provided. All other transformers shall meet the following requirements.

3.8.1.16.6.1 Transformers, Inductors, and Coils.- Transformers, inductors, and coils shall be in accordance with the table below and with FAA-G-2100, paragraphs 3.5.5.24. Transformers and inductors used for audio, power, and high power pulse shall have solder-type or screw terminals. Single phase AC line operated transformers shall not have more than three secondary windings and one centertap.

SPECIFICATION	GRADE	TEMPERATURE CLASS
MIL-T-27 (See note)	4 or 5	R
MIL-T-21038 (See note)	4 or 5	R
MIL-C-15305	1	B
MIL-C-39010	-	B

(NOTE: Life expectancy X, MIL-T-21038)

Transformers, inductors, and coils shall be designed and built per the requirements of MIL-T-27, but will not be tested per MIL-T-27. All testing shall be as part of a larger subassembly or assembly with the following provisions:

Should a part fail twice during any Phase I, II, III, or IV test, the contractor shall perform all tests required by MIL-T-27 for parts of the type that failed. A part is defined as any transformer, coil, or inductor required to be designed and tested per MIL-T-27. Since the reliability calculations for the individual MIL-T-27 parts far exceed the 20-year life expectancy of the ARSR-4 system, two failures of the same type part will invoke full compliance of MIL-T-27 testing for that part. Additionally, the contractor shall retrofit all existing ARSR-4 systems at no added cost to the Government.

3.8.1.16.7 Batteries.- In the event that batteries are provided to meet the requirements for operation, only rechargeable batteries with appropriate recharging circuitry shall be provided, used, and their selection shall be in accordance with FAA-G-2100, paragraph 3.5.5.1; except that magnesium dry batteries are not permitted. Individual batteries shall be completely sealed and shall not vent gases, liquids, or chemicals except in the event of physical damage by external mechanical means. The battery supply shall not be sensitive to orientation of the equipment during operation, transportation, or storage. Exceptions to this requirement, such as "keep-alive" batteries for clocks and memories, shall be subject to Government approval.

3.8.1.16.8 Electrical Filters.- Electrical filters, except radio interference filters, shall be selected in accordance with FAA-G-2100 paragraph 3.5.5.7. Radio interference filters shall conform to MIL-F-15733.

3.8.1.16.9 Ferrous Materials.- When ferrous materials are used with prior approval of the Government, they shall be in accordance with FAA-G-2100, paragraph 3.6.4.

3.8.2 Electrical Requirements.-

3.8.2.1 Transient Protection.- All equipment shall be protected from damage by electrical transients as defined in FAA-STD-020.

3.8.2.1.1 Surge Protection.- Protective devices shall be provided as necessary to prevent damage to the equipment from surges on either the AC power lines, or the remoting lines. The protective devices shall be capable of limiting initial spikes, as might result from nearby lightning strikes, to a value that will not damage any equipment. The protective devices shall be capable of withstanding repeated surges without damage or change in operating characteristics. The protective devices shall be in accordance with the applicable parts of paragraph 3 of FAA-STD-019 and paragraph 3 of FAA-STD-020.

The ARSR-4 shall not output false operational or maintenance signals as the result of turning on or off any off-line unit (if provided), or any LRU therein, or any LRU in the on-line unit.

3.8.2.2 **Ripple Voltage**.- Ripple voltage, defined as the peak-to-peak value of a simple or complex waveform consisting of power line frequency components and harmonics thereof, and synchronous or repetitive nonsynchronous transients, shall not exceed 10 mV or 0.1 percent, whichever is greater, for all except switching type power supplies. The contractor shall be responsible for determining the maximum permissible level of ripple from switching power supplies required for specified equipment performance characteristics.

3.8.2.3 **System Grounding Requirements**.- Requirements for grounding, shielding, bonding, and transient protection shall be as specified in FAA-STD-020.

3.8.2.3.1 **Grounding Practices**.- The Government will furnish the earth ground and AC power ground at installation locations. The contractor shall furnish all other grounds as required by FAA-STD-020.

3.8.2.3.2 **System Grounding**.- A common system grounding design shall be used for all subsystems and units to be delivered under this specification. The grounding design shall contain three discrete subsystems:

    — (a)   One that bonds together all cabinets and frames and shall be in accordance with FAA-STD-019 and FAA-STD-020.

      (b)   One that connects all signal return wires and shall be in accordance with FAA-STD-019 and FAA-STD-020.

      (c)   The AC power grounds shall be in accordance with FAA-STD-019 and FAA-STD-020.

3.8.2.4 **Power Supply Protection**.- For loads up to 1.5 times the normal load, power supplies shall maintain an essentially constant voltage characteristic. For any continuous load in excess of 1.5 times the normal load, up to and including a dead short, current limiting shall occur such that no damage is incurred by any power supply parts; no circuit breakers are tripped; and the power supply voltage returns to normal when the normal load is restored.

3.8.2.4.1 **Load Protection**.- Instantaneous overvoltage protection (e.g., crowbar type circuitry) shall be provided on all power supplies used to drive voltage-critical devices. There shall be no transients or surges at turn-on, or upon restoration of power following a power loss, that could cause equipment failures or circuit breakers to trip. The equipment shall automatically disconnect the voltage from circuits which would be damaged by loss of, or deviation from, its normal value of bias voltage. Load point regulation shall be employed as required to insure that voltages as measured at the load are within the nominal range for driven circuitry.

3.8.2.4.2 Regulation.- All power supplies shall be electronically regulated to maintain output voltages within ± 1 percent as the load is varied from 20 percent less than, to 50 percent more than, the normal load; and as the line voltage is varied between service condition limits, with primary power line regulators (if used) in the circuit. The output voltages of these regulated supplies shall be adjustable to any value over a range of + 10 percent of the nominal value, and the regulation ripple specifications shall be met for any and all settings within this range. Power supply output voltage shall not change by more than ± 1 percent from the initial setting over the service conditions. The regulation and ripple requirements are minimum requirements, and it shall be the contractor's responsibility to design the equipment with such additional reduction in ripple and improved regulation as is required to meet all specified performance requirements. A separate, independent voltage reference solid state device shall be used for each regulated power supply voltage, and the regulation of one power supply voltage shall not depend on another power supply voltage for reference.

3.8.2.4.3 Power Supply Indicators.- Each circuit protected by a circuit breaker shall have an indicator lamp which shall provide positive indication when the circuit breaker is opened. Neon indicator lamps shall be used where possible. Indicator lamps shall be uniformly located with respect to their associated circuit breakers. Each power supply shall also have an integral indicator lamp to show when the power supply itself fails, as contrasted to a fault which would trip the breaker. Each power supply failure shall be reported to the RMS.

3.8.2.4.4 Power Supply Metering.- Meters and associated switches for use in measuring all power supply output voltages and currents shall be furnished. The preferred location of these switches is on the front panels of the cabinet containing the circuits to be metered. They may be located elsewhere, provided they are visible with the cabinet doors opened. Meters are not required where the RMS has an equivalent direct reading capability or the contractor and the Government mutually agree that voltage test points would be sufficient. Each meter shall be provided with a replaceable card insert mounted near the meter to designate the proper reading of each associated switch position. Operation of meter selector switches shall not interfere with proper subsystem and system performance. When shunts are used in conjunction with meters to read currents, especially specified meter movements over and above military specification requirements shall be employed with the resistance of the meter movement held to close tolerances to permit a 3 percent overall accuracy in true load current measurements. Meter calibration test points shall be provided across each meter.

3.8.2.5 Electromagnetic Interference and Susceptibilities.- The equipment shall be designed and constructed to meet the interference and susceptibility requirements of MIL-STD-461 and MIL-STD-462 for Class A3 equipments with the following exceptions. For test CE03 (broadband) in MIL-STD-461C, the specification limit shown in Figure 2-3 shall be changed to be a line extending from 160dB above 1µA/MHz at 15kHz to 50dB above 1µA/MHz at 6MHz to 50dB above 1µA/MHz at 50 MHz. For test RE02, the limits shall be those specified in MIL-STD-461D for test RE102 except that the limit at 21.6MHz shall be 55dBµV/m. The contractor shall prepare and submit an interference control plan in accordance with the SOW.

3.8.2.6 Electrostatic Sensitive Parts.- Certain types of electrical and electronic parts are susceptible to electrostatic discharge damage. The contractor shall implement and maintain an Electrostatic Discharge Control Program in accordance with DOD-STD-1686.

3.9 Maintenance and Logistics.- The contractor shall design the ARSR-4, both electrically and mechanically, to promote the Maintenance Concept and Logistic Approach in the following paragraphs.

3.9.1 Maintenance Concept.- A three-level maintenance concept shall be employed for the ARSR-4. These three levels are as follows:

(a) Site (organizational)

(b) Shop (intermediate)

(c) Depot

The locations at which the respective maintenance tasks will be performed are as follows:

(a) ARSR-4 sites

(b) Work center

(c) FAA depot

3.9.1.1 Site-Level Maintenance.- Maintenance is performed at this level on systems, subsystems, and support equipment in direct support of ARSR-4 operations. It includes system maintenance monitoring, system fault isolation, and correction of system failures through the removal and replacement of LRUs; but does not include disposition, repair, service, calibration, and verification of the removed LRUs. Removed LRUs will be forwarded to the work center and/or depot for repair.

3.9.1.2 Work Center Level Maintenance.- Maintenance is performed at this level in direct support of site-level maintenance and involves disposition, repair, service, calibration, and verification of units removed during site maintenance. It normally excludes activities requiring equipment, facilities, or skills that can be provided more economically at the depot level.

3.9.1.3 Depot Level Maintenance.- This level of maintenance includes the responsibility for repair of LRUs, such as printed circuit boards, which are beyond the economic or skill capability of the work center maintenance level.

3.9.2 Logistics.-

3.9.2.1 Support and Test Equipment.- Support and test equipment shall be identified and documented in accordance with the SOW.

3.9.2.1.1 System Level Test Equipment.- The test equipment necessary for system maintenance, i.e., fault isolation down to the LRU level, shall be kept to a minimum. These functions shall be primarily performed by BITE and diagnostics in the ARSR-4.

3.9.2.2 Parts Selection.- The ARSR-4 design shall make maximum use of standard, approved parts already in the Government inventory.

3.9.2.3 Personnel.-

3.9.2.3.1 Maintenance Personnel.- There are four major maintenance functions (monitoring, diagnostic, repair, and preventive maintenance) that must be quantified and supported by maintenance personnel per FAA delineation of personnel levels. The ARSR-4 shall be maintainable by personnel defined by these levels.:

(a) Developmental Specialist: An uncertified technician who performs maintenance tasks at the site, shop, or depot level.

(b) Systems Specialist: A certified technician who performs maintenance tasks at the site, shop, or depot level.

(c) Systems Analyst: An analyst who provides the in-depth system skills necessary to diagnose and resolve complex and difficult problems related to a specific system and its interfaces. These analytical and trouble-resolving skills would be beyond those expected of a systems specialist.

(d) Systems Engineer: An engineer who provides systems management and control for all systems and provides the broadest range of systems knowledge and expertise to ensure real-time quality control and system integrity.

3.10 ARSR-4 Program Support Facility (PSF).- The ARSR-4 PSF shall be an independent facility, collocated with the ARSR-4 to be installed at the FAA Aeronautical Center at Oklahoma City, Oklahoma. The ARSR-4 PSF shall include all of the equipment, supporting software and firmware, and documentation required for the development, maintenance, testing, analysis and debugging all of the ARSR-4 functional programs. The ARSR-4 at the Aeronautical Center will be available to the users of the ARSR-4 PSF. The ARSR-4 PSF shall include the capability to execute the ARSR-4 operational program with the tools used during software development.

3.10.1 Processors.- The internal ARSR-4 PSF processors shall include sufficient memory and power to support six simultaneous users who may be performing any of the following:

(a) Text editing

(b) Program assembly or compilation

(c) Linking or loading programs appropriate to software maintenance

(d) Performing analysis

(e) Running functional programs.

3.10.2 Software Tools.- The ARSR-4 PSF shall be equipped with software tools identical to those used in developing the ARSR-4 operational and support computer programs.

3.10.3 Input/Output Hardware.- The ARSR-4 PSF shall support six, on-line, locally netted users stations. Equipment shall include an appropriate mix of interactive CRT terminals, video display terminals, magnetic tape assemblies, multi-platter disk drives and controllers, and printers as specified in the contract.

3.11 Computer Software.- The term "software" as used in this specification shall apply to all deliverable items having one or more of the following characteristics:

(a) Computational and control logic represented in a higher order language or assembly language form and defined as source code to be interpreted, assembled, or compiled into machine executable form.

(b) Executable program instructions at the microcode or direct machine executable levels.

(c) All data representations required by executable program logic.

These deliverable items are further identified as being processed/executed on computational/control hardware. This hardware consists of CPUs or programmable controllers/devices or both, whether used as general purpose (as in the computer subsystem) or dedicated hardware.

All items meeting the above criteria shall be subject to the software requirements of this specification. Exceptions shall be made only upon written authorization by the Contracting Officer.

3.11.1 Development Planning.- All software shall be designed and implemented in accordance with a government approved Software Development Plan (SDP) prepared in accordance with the SOW and DOD-STD-2167 design standards. In addition, the software design shall accommodate the following requirements.

(a)   Identical software, adapted to the local resources, environment, and workload, shall be installed in each site. Local "patches" to executable code and data tables shall not be used.

(b)   Design emphasis shall be placed on reliability, error detection and reporting, fault tolerance, and recovery from abnormal conditions, as well as functional performance.

(c)   The design shall support subsystem and system modification, enhancement, and expansion throughout the expected lifetime of the ARSR-4. Provision shall be made in instruction code, data tables, and data bases, to accommodate additional functions, new equipment, and new data.

(d)   The software design shall provide logical and physical data independence. Changes made to the logical structure of the data shall not impact the application programs. Changes made to the physical structure of the data shall not impact the logical structure of the data or the application programs. The ARSR-4 software shall permit changes to both the form of storage and to the position of data in the storage without impact to the application programs or the logical structure of the data.

(e)   The software design shall provide data integrity. It shall protect data from accidental loss or damage.

(f)   The software design shall provide a controlled approach to adding new data and to modifying and retrieving existing data. It shall provide logical data to the application programs as required. It shall provide status information to the application programs on the outcome of data requests, including error indications.

(g)   The software design shall assure that the system is initialized to a correct, well defined state upon recovery from a fault, and that all processing interrupted by a fault is properly continued after recovery.

(h)   The software design shall incorporate a responsive real-time operating system with a standard compiler, loader, software development library (SDL), and other debug and utility tools.

(i)   All software shall, when loaded, generate a load message to the operator to supply the software name or function, the software release and revision level, and the Site ID, if applicable.

3.11.2 Software Architecture.- The architecture shall minimize the complexity of interfaces between software units and keep unrelated functions separated. The software requirements shall be decomposed into computer software configuration items (CSCI), top level computer software components (TLCSC), lower-level computer software components (LLCSC), and units, using a top down approach. There shall be design traceability between successively more detailed levels of abstraction from the most abstract level to a level sufficient for code implementation. Each level shall be complete and independent, containing definitions of data and the operations on the data.

3.11.2.1 Unit Attributes.- The software design shall be functionally and operationally unitized as specified in DOD-STD-2167 to:

(a) Facilitate system and subsystem expansion, modification, and configuration control.

(b) Enhance system reliability for facilitating fault detection, diagnosis, containment, recovery, and fault-tolerant behavior.

(c) Facilitate data base changes to the lowest practical level without large program reassemblies.

Each unit shall perform a single unique function, with inputs, outputs, and interunit interfaces clearly defined. Each unit shall be separately compilable.

Each unit shall consist of a specification part, data declarations, and sequence of statements. The specification part shall contain the information necessary to use the unit without describing the internal details of how the unit operates. The data declaration shall define the logical entities needed by the unit, and the sequence of statements shall define the operations to be performed.

Only statements within a unit shall access private data of that unit. Other units shall access through interfaces provided by the unit.

3.11.2.2 Design Representation.- The design shall be represented in a manner which ensures traceability to the requirements of this specification. The representation shall be maintained as part of the design data base.

3.11.2.3 Software Documentation/Implementation.- All software shall be documented in accordance with the requirements specified in the SOW and throughout this specification. All software shall be implemented in accordance with the standards established in the SDP in the SOW.

3.11.2.4 <u>Code Representation</u>.- A single Higher Order Language (HOL) shall be used for support software and this HOL or another single HOL shall be used for the operational software with the exception of LDC software. The LDC software shall use either the HOL used for the operational software or PLM. One of the following HOLs which uses a compiler shall be used for either the support software or for the operational software, or both.

    (a)   C

    (b)   Fortran

    (c)   Modula 2

    (d)   Pascal

An Assembly language instead of an HOL may be used in the ARSR-4 operational software within the following conditions:

    (a)   Less than 10,000 lines of code of the total operational software, excluding the operating system, may be in Assembly language.

    (b)   Assembly language shall only be used in areas of time criticality, I/O, and interfacing to the operating system.

    (c)   Technical justification for each module of Assembly language code developed for the operational software shall be provided to the Government.

    (d)   Off-the-shelf non-operational code such as compilers, linkers, host operating systems, etc, may be in Assembly language.

    (e)   All software written for the PSF will be in an HOL.

3.11.3 <u>Special Tools, Standards, and Techniques</u>.- Automated tools shall be used to support the software development process, and to record, analyze, and maintain the ARSR-4 software design. The specific tools and techniques to be used shall be identified in the software development plan in accordance with DOD-STD-2167.

The tools shall be applicable throughout the software development and maintenance life cycle. They shall address all aspects of software design; including algorithms, data structures and files, and interfaces. The tools shall encourage and facilitate design of software in accordance with approved design techniques and standards.

All software tools or techniques used to support software development and implementation, along with sufficient documentation to allow an operator to understand and use these tools, shall be delivered to the government as part of the ARSR-4 PSF (3.10). All software, including commercially available software, provided as part of the ARSR-4 PSF shall be evaluated and documented in accordance with DOD-STD-2167.

3.11.4 Not used.-

3.11.5 Software Reliability Design Features.- ARSR-4 software shall have the following reliability and quality characteristics.

(a) Fault Avoidance - The software shall be specified, designed, and implemented to achieve high reliability in accordance with the detailed software design and construction requirements presented in 3.11.

(b) Fault Detection - Reasonableness detection/isolation checks shall be designed into the software to aid in troubleshooting system and subsystem failures.

(c) Fault Tolerance - The software shall provide fault tolerant mechanisms that ensure continuing required functions without causing an interruption in service. These techniques include, but are not limited to:

(1) Recovery block schemes (which cause switching to a spare block of code).

(2) Protective redundancy (which includes multiple storage of critical variables and data, diagnostic programs, and automatic program reloads).

(3) The BTP and the search target processing, up to the output of the target extraction function, shall be designed to handle the maximum possible data load for the full search detection envelope. From the output of the target extraction function to the output buffers of the message formatting function, the system shall handle the maximum data load that can occur based on the clutter model (appendix A). If the actual clutter conditions encountered at any ARSR-4 site are greater than those specified in the clutter model (Appendix A) and Table 3-1, the system shall still have the capacity to contend with any maximum data load. In no case shall a data overload cause the system or any part of the system to fail.

(d)   Fault Containment - The following fault containment considerations shall be incorporated into the ARSR-4 software design.

      (1)   The software design shall provide protection against the propagation of software errors. No information shall be passed unless computer software component error boundary conditions are satisfied.

      (2)   The system shall detect errors in operation or data introduced by incorrect synchronization of software.

      (3)   Search data overload conditions shall not impact beacon target processing or reporting.

3.11.6 Software Maintainability.- ARSR-4 software shall have the following maintainability characteristics:

(a)   Software performance monitoring and software maintenance operations shall not interrupt normal system operation.

(b)   ARSR-4 software shall be designed as a collection of software units.

(c)   All software units pertaining to the operational software shall be written in the same HOL. All software units pertaining to the support software shall be written in the same HOL. Software languages acceptable for use are listed in 3.11.2.4.

(d)   Each software unit shall include error detection and exception handling capabilities.

(e)   Each unit shall be separately maintainable.

3.11.7 Firmware.- Computer programs or microprograms that are loaded in a class of memory (Read-Only Memory (ROM), Programmable Read-Only Memory (PROM), or writable control store) that cannot be dynamically modified by the computer during processing shall be considered firmware and shall be developed according to DOD-STD-2167. The application of DOD-STD-2167 requirements and documentation depends on whether the firmware is designated as a CSCI or as part of a hardware configuration item (HWCI). If the software to be implemented in firmware is designated as a CSCI, all the requirements in DOD-STD-2167 apply, as tailored by the contract. If the software to be implemented in firmware is considered part of the HWCI, the contractor shall identify the requirements, specified herein, in the SDP and apply these requirements subject to government approval.

3.11.8 <u>Microprogramming</u>.- The government considers microprogramming to be a method of implementing the control functions of a processor (microprocessor or large scale processor). Requirements for modifications or additions to the control functions (microprogramming) shall be submitted by the contractor and approved by the government prior to implementation. All microprogramming shall be compliant with requirements concerning maintainability, reliability, and documentation stated within this specification.

3.11.9 <u>Computer Programs for Microprocessors</u>.- Computer programs (software) intended for execution on a microprocessor shall be considered to have the same requirements as computer programs intended for execution on large scale processors. Such computer program implementations shall be subject to all software constraints and requirements. All microprocessor implementations shall be compliant with requirements concerning maintainability, reliability, and documentation stated within this specification.

3.11.10 <u>Software Spare</u>.- At system acceptance following Qualification Test and Evaluation (QT&E - Phase 1 and Phase 2), the data processing configuration shall provide the following margins for spares and growth while meeting the delay requirements of paragraph 3.4.1.14 with the user configuration described in paragraph 3.5.13(i). This spare and growth shall also apply to data processing accomplished on microprocessors and microcomputers.

(a) Primary memory spares. The computer configuration shall include at least 100 percent addressable contiguous spare capacity in all computer modules and data structures with no modifications in the equipment, no restructuring of modules, and no restructuring of I/O operations. At the completion of Phase IV testing, each ARSR-4 shall have a minimum of 90 percent of spare memory remaining unused.

(b) Mass storage spares. The computer configuration shall include at least 100 percent addressable contiguous spare capacity in all data structures contained in mass storage with no modifications in equipment, no restructuring of modules or data structures and no resequencing of I/O operations. However, 10,000 bytes of memory from this additional storage capacity may be used while transitioning from ARTCCs to ACFs. At the completion of Phase IV testing, each ARSR-4 shall have a minimum of 90 percent of spare memory remaining unused.

(c) CPU spares. Under worst case CPU loading (over a 1/2 scan period), the delivered CPU usage (processing time) shall not be greater than 50 percent of capacity.

(d) Upward growth. The delivered configuration shall either include, or permit by addition, units without induced change, modification, redesign of power supplies and air conditioning; or redesign in software/firmware/hardware, a further 100 percent increase in capacity of prime memory and mass storage device (e.g., if a processor can address 512,000 memory locations, then not more than 256,000 locations may be used to satisfy item b above and all delivered software must operate with 128,000 locations in accordance with item a above). All growth shall be addressable in the delivered configuration.

4.0 Quality Assurance Provisions.- This section establishes the requirements and criteria for verification of the ARSR-4 performance and characteristics. The scope of these requirements includes the system itself, all functional areas within the system, the radome, and all internal and external interfaces. Verification is accomplished in phases throughout system acquisition. All verifications shall be accomplished to the satisfaction of the Government unless signed waivers are obtained from the Contracting Officer. The Government shall have the right to witness and reaccomplish any or all tests.

4.1 General Quality Assurance Requirements.- The basic objectives of the quality assurance requirements are to provide early visibility of, and confidence in, ARSR-4 system characteristics and performance parameters and to assist in the verification of section 3 requirements as early as possible. The final results of the quality assurance program will be a high degree of confidence that the implemented ARSR-4 system meets all the requirements of section 3 in its intended operational environment. Quality assurance shall be obtained by Government verification conducted in phases; each phase designed to provide increased assurance that required system program objectives will be met. Verification shall be considered complete upon satisfactory completion of all phases of testing. Except for the maintainability and reliability demonstrations, objectives of an earlier verification phase must be satisfied, and deficiencies must be resolved, before a later verification phase is initiated. The results of each verification phase shall determine the advisability of proceeding to the next phase. The quality assurance phases shall be as follows:

(a) Phase I, In-Plant Qualification Test and Evaluation (In-Plant QT&E).

(b) Phase II, On-Site Qualification Test and Evaluation (On-Site QT&E).

(c)   Phase III, In-Plant Production Acceptance Test and Evaluation (In-Plant PAT&E).

(d)   Phase IV, On-Site Production Acceptance Test and Evaluation (On-Site PAT&E).

4.1.1 Verification Phase Description.-

4.1.1.1 Phase I In-Plant QT&E.- This phase of testing and evaluation shall provide answers, as early in the program as feasible, to the majority of the critical questions and areas of risk associated with development of the ARSR-4. This verification activity also demonstrates that engineering design and development are complete, that design risks have been minimized, and that the system can be expected to meet engineering and operational specifications. It shall identify the degree to which the contract specifications have been met, insure system compatibility, and provide estimates of system reliability/maintainability/availability performance. Verification proceeds from the unit level, through integrated verification of functional areas and interfaces within the complete system, and to the complete system, in as near an operational configuration and environment as practical. In-Plant QT&E shall be conducted on units, subsystems, and the entire system during development and, in general, prior to on-site operational testing. Verification of equipment performance and proper interfacing with all EIE and with the ARTCC, FAA Technical Center, SOCC, and the ROCC System Support Facility (RSSF) shall be accomplished during this phase. Flight testing and analysis shall be conducted by the Government in conjunction with the contractor. When clutter processing, false report rates, and target detection capabilities are verified by this Phase of testing (e.g., via flight testing; measuring transmitter stability, dynamic range, subclutter visibility, receiver sensitivity; filter shaping and waveform analysis; CFAR and thresholding analysis; etc.), the clutter conditions specified in Appendix A and Table 3-1 shall be used as the minimum clutter levels to which the contractor proves to the Government that the system is performing to the specified level of performance.

4.1.1.2 Phase II On-Site QT&E.- The purpose of On-Site QT&E is to emphasize quality and visibility of the design when it is subjected to a test site and the live air traffic environment. Phase II shall be conducted at the Government designated radar facility. External operational system interfaces shall be with the FAA's and USAF's control centers, the FAA Technical Center, the RSSF, and with all other site equipment. Verification shall emphasize operational parameters not feasible to test or evaluate in the factory environment. Verification shall include installation and system check-out verification, verification of the integrated functional areas within the complete system, and verification of the complete system in the field environment. These tests shall be conducted by the contractor and witnessed by the Government. Testing shall be conducted using live inputs and recorded or simulated inputs as necessary for verification of specified ARSR-4 performance parameters in an operational environment. Flight testing and analysis shall be conducted by the Government in conjunction with the contractor. When clutter processing, false report rates, and target detection capabilities are verified by this Phase of testing (e.g., via flight testing over or in, or both, clutter; measuring false reports; measuring clutter intensities and spectral qualities; etc.), the clutter conditions actually experienced at the site shall be used as the baseline to which the contractor proves to the Government that the system is meeting the specified requirements for each individual site. However, the clutter conditions specified in Appendix A and Table 3-1 shall be used as the minimum clutter levels to which the contractor proves to the Government that the system meets the specified requirements, if the actual site clutter levels experienced are less intense.

4.1.1.3 Phase III In-Plant PAT&E.- This series of verification tests provides confidence that the production units, equipment, and systems meet the contracted specifications. Verification of units and functional areas of complete systems shall be conducted in the contractor's plant prior to shipment to the site. When clutter processing, false report rates, and target detection capabilities are verified by this Phase of testing (e.g., measuring transmitter stability, dynamic range, subclutter visibility, receiver sensitivity; filter shaping and waveform analysis; CFAR and thresholding analysis; etc.), the clutter conditions specified in Appendix A and Table 3-1 shall be used as the minimum clutter levels to which the contractor proves to the Government that the system is performing as required.

4.1.1.4 Phase IV On-Site PAT&E.- The installation at the site will proceed in accordance with the SOW. The contractor shall fully interface the ARSR-4 with the FAA and USAF control centers and all EIE as specified. Then, verification with Phase IV shall commence. The purpose of this verification phase shall be to ensure system compliance with all applicable requirements prior to final ARSR-4 acceptance by the Government. When clutter processing, false report rates, and target detection capabilities are verified by this Phase of testing (e.g., via flight testing over or in, or both, clutter; measuring false reports; measuring clutter intensities and spectral qualities; etc.), the clutter conditions actually experienced at the site shall be used as the baseline to which the contractor proves to the Government that the system is performing as required for each individual site. However, the clutter conditions specified in Appendix A and Table 3-1 shall be used as the minimum clutter levels to which the contractor proves to the Government that the system meets the specified requirements, if the actual site clutter levels experienced are less intense. At the completion of Phase IV testing, each ARSR-4 shall have a minimum of 90 percent of spare memory remaining unused.

4.1.2 Quality Assurance Program.- The contractor shall provide and maintain a Quality Assurance Program in accordance with the contract.

4.1.3 Test Plans.- The overall test control document, the Test and Evaluation Plan, shall be provided by the contractor for Government approval. The Test and Evaluation Plan shall be developed in accordance with FAA-STD-024, (This Test and Evaluation Plan is called "Master Test Plan" in FAA-STD-024, but shall be referred to in this procurement program as "Test and Evaluation Plan" and meet all requirements in FAA-STD-024 specified for the Master test Plan) and shall contain separate sections covering all test phases (Phase 1 through Phase 4) specified herein. The submission and approval of test procedures shall be as specified in the SOW. Test procedures shall list all test equipment and software required. Test equipment descriptions shall include make, model, serial number, and certification data. All the tests specified herein shall be a part of the Test and Evaluation Plan and shall identify all in-process and acceptance tests to be performed on units, subsystems, and systems to demonstrate compliance with all contract requirements.

4.2 Phase I In-Plant QT&E.- Phase I shall consist of the inspections, analysis, demonstrations, and tests performed on a system, subsystem, and unit (e.g., Antenna, Transmitter, Receiver, Search Target Processing, BTP, RMS, Weather Processor, etc.). The Government will provide one set of Mode 4 peculiar EIE to allow the contractor to conduct design qualification tests upon the security containers electrical and physical design. As a minimum the following shall be accomplished:

(a) Type Test

(b) Design Qualification Tests

(c)   System Coverage Verification

(d)   Preliminary tests per FAA-G-2100

(e)   Production acceptance tests

(f)   Reliability demonstration

(g)   Maintainability demonstration

(h)   Software tests

(i)   Items identified in the Quality Verification Matrix

(j)   24-hour continuous operation test

(k)   Radome materials tests

(l)   Interface tests

4.2.1 Type Test.- The Phase I Type Test performed under the service conditions shall be performed in accordance with 4.3.3 of FAA-G-2100. The complete ARSR-4 design shall be tested under service conditions as specified in 4.11 of FAA-G-2100. The contractor shall provide the capability to externally monitor the performance of all equipment during type testing. Antenna type testing may be performed separately from the rest of the ARSR-4 system. Requirements for antenna type testing may be met by type testing the antenna electronics, the pedestal with an equivalent load, and any other antenna active elements separately in the test chamber.

4.2.1.1 Type Test Requirements.- The contractor shall submit type test procedures and test data sheets for approval by the Government. System performance shall be monitored during type testing in accordance with FAA-G-2100. The proper operation of the equipment being type tested shall be verified before and after each type test.

4.2.2 Design Qualification Tests.- Design qualification tests shall include tests specified in subparagraphs hereunder and those specified in paragraph 4.3.2 of FAA-G-2100. Radome design qualification tests shall be conducted under the environmental conditions specified in 3.4.6 herein.

4.2.2.1 Antenna Assembly and Alignment.- The antenna shall be assembled and aligned in accordance with procedures contained in the instruction manuals and utilizing only those alignment fixtures and tools provided or normally available for field installation. Sufficient antenna testing shall then be performed to demonstrate that the antenna can be field installed with resultant performance in accordance with specified requirements.

4.2.2.2 Antenna Manufacturing Contour Tolerance Test. - The contractor shall demonstrate the integrity of the antenna structure when the antenna is under a load caused by rotation. This test shall be performed with all three beacon antenna configurations (3.5.2.1) mounted on the ARSR-4 antenna. A radiation pattern through each beam's principle axis shall be measured in the horizontal and vertical plane. The antenna shall be under a load which is at least equal to the windload caused by its rotation in the radome. The test may be conducted with the antenna either statically loaded or with the antenna rotating at a rate of at least 5 RPM. The contractor shall submit a detailed description of the proposed static load test for Government approval.

4.2.2.3 System Alignment. - The system shall be completely aligned utilizing only the procedures contained or to be contained in the instruction manuals and the test equipment in accordance with the SOW. Sufficient testing shall then be performed to fully determine the adequacy of the manuals and the test equipment for optimizing system performance.

4.2.3 System Coverage Verification. - System performance characteristics shall be measured as necessary to verify the specified system coverage and false alarm rate of section 3. Utilizing the actual measured values, range calculations shall be performed, with the results verifying the detection requirements of 3.4.1.2 and Table 3-1 for clear environment and the false alarm requirements of 3.4.1.6. Flight testing in accordance with the SOW shall be accomplished at the contractor's facility. The system shall operate with the radome installed during all flight testing. As many section 3 (including Table 3-1) detection requirements as possible shall be verified during this test. Detection performance requirements of section 3 shall also be verified during Phase II at a field site selected by the Government.

The flight testing specified herein shall use a T-38 aircraft which shall be supplied by the Government. The T-38 has a RCS of 2.2m² and shall be assumed as having Swerling I characteristics. Any other aircraft needed for performance verification shall be an aircraft mutually agreed upon by the Government and the Contractor.

4.2.4 Preliminary Tests. - The contractor shall perform preliminary tests in accordance with paragraph 4.3.1 and its subparagraphs in FAA-G-2100.

4.2.5 System and Subsystem Production Acceptance Test. - Each ARSR-4 delivered under the contract shall be completely wired and assembled in its final installed configuration for the system production tests at the contractor's manufacturing location. System production testing shall be performed with the equipment fully assembled and operable and radiating as a complete system. Antenna testing may be performed separately, if necessary; however, an installed antenna complying with all performance requirements specified herein shall be available for system testing. Production tests of the contractor-modified security containers shall consist of cabling tests. The Government will install and test the Mode 4 peculiar EIE equipment at the radar site.

In addition to appropriate mechanical and electrical tests, the contractor shall generate a set of antenna radiation patterns on each antenna and its associated equipment. The test shall be conducted on an antenna test range meeting the requirements specified in Appendix E. Antenna testing during Phase I shall be accomplished with the one beacon antenna mounted, with two beacon antennas mounted, and without any beacon antenna(s) mounted as specified in 3.5.2.1. At least three antenna patterns shall be generated for each antenna produced, verifying all applicable requirements, such as antenna beamwidth, antenna gain, cross polarization ratio, circular polarization cancellation ratio (if applicable), the requirements of 3.5.2, etc. Each set of patterns shall be taken at a discrete test frequency and pointing angle. The set of frequencies and pointing angles used to test each individual antenna shall be randomly selected and be unique to that antenna. The test frequencies used shall be distributed across the low, middle, and upper part of the operating band to assure that antenna pattern anomalies related to frequency that are detrimental to system performance are not present. The minimum separation between the test frequencies shall not be less than 25 MHz.

4.2.5.1 <u>Production Tests</u>.- The following listed test items (where applicable), as a minimum, shall be performed on each ARSR-4 to be delivered to the Government in order to demonstrate compliance with specified requirements.

Transmitter peak power
Pulsewidth
Average PRF
Noise figure
Receiver sensitivities
System stability
Capacity
RF pulse radiated spectrum
TR device, recovery time
STC RF plumbing, pressurization integrity
Trigger requirements
Clutter processing performance
Test target generator

RFG performance
Point of control
Alarm controls
Search target processing
Beacon target processing
Weather Channel
Five level weather
RMS
Mode 4 processing performance
Formatter performance
Automatic Ka insertion from
   the on-site weather station

4.2.6 <u>Reliability Test and Evaluation</u>.- The contractor shall perform a reliability demonstration test on a complete ARSR-4 radar, including the antenna. The reliability demonstration shall be performed at the contractor's test facility and will be witnessed by the Government. The quantitative reliability levels required by 3.4.3.1 shall be verified by the following.

4.2.6.1 <u>Reliability Analysis</u>.- The final approved reliability analyses for the various configurations and worst case environments shall demonstrate compliance with the quantitative requirements specified in 3.4.3.1

4.2.6.2 Reliability Verification Test (RVT).- The Contractor shall demonstrate that the reliability requirements of a fully operational ARSR-4, including the radome and all radome ancillary equipment, have been achieved by conducting a controlled Reliability Verification Test (RVT). The RVT operating time shall be 6,000 hours as specified in 4.2.6.2.2, and shall be conducted at the contractor's plant on a single dedicated system. A precondition of this test is that the reliability predictions performed in accordance with the SOW shall be at least 1500 hours MTBCF. All site adjustable/selectable parameters shall be set to positions determined by the Government prior to the start of testing. These parameter adjustments and selections shall remain unaltered during the course of the test. Field adjustable/selectable parameters may be altered only by the Government during the course of the test in order to simulate field conditions. The RVT system, including system controls, shall be sealed to assured that no failure (hardware or software) is corrected, manually or automatically, without recording and witnessing by the Government. Once the RVT has begun, the system shall be continuously monitored by contractor personnel. The environmental test conditions and stress levels for the RVT shall be those specified in Appendix B, MIL-STD-781 for Category 1 (fixed ground equipment), but excluding vibration stress and humidity. The system shall be operated continuously except for permitted shutdowns for maintenance and critical failures, until the observed reliability requirements of 4.2.6.2.2 and 4.2.6.2.3 have been met. During the 6000 hours of operating time for which the specified MTBCF and MTBF are demonstrated, a maximum of seven site visits for the combination of corrective (noncritical failures) and preventive maintenance are allowed, in addition to the site visits to correct critical failures. During the visits to correct critical failures, other maintenance (corrective and preventive) can be performed. Response time (i.e., time from failure detection until start of corrective action) for critical failures shall be exactly two hours. Response time for other maintenance (corrective or preventive, or both) shall be 48 hours or greater.

Any of the specified corrective or preventive, or both, maintenance site visits (other than for critical failures) that will result in an outage shall meet the following requirements:

(a)   It shall be scheduled with at least one week notice in advance.

(b)   It shall be performed no more frequently than once every 91 days.

(c)   It shall not exceed two hours outage per visit.

Preventive maintenance shall require no more than a total of 17 labor hours over the 6000 hours for which the specified MTBCF and MTBF are demonstrated. Each failure shall be recorded, analyzed, and corrected by repair and by design or manufacturing changes to cure the identified cause of the failure. The Government will witness each time the system is maintained to assure that each failure is recorded and that preventive maintenance, corrective maintenance and incorporation of design and manufacturing improvements are done in accordance with prescribed maintenance procedures or approved system improvements.

The contractor shall demonstrate the separate mission reliability requirements of the antenna (3.4.3.1.1) and RMS (3.5.15.8.9) have been achieved by conducting controlled reliability tests for each one, independent of the other reliability test. These tests shall start at the beginning of the full system RVT specified herein, and shall be performed simultaneously with the full system RVT on the same system. The contractor shall also show by a combination of analysis and test that the separate reliability requirements specified herein for the radome (3.4.3.1.5) is verified. Additionally, the RMS, antenna, and radome failures shall be counted against the full system RVT. During these reliability demonstrations, the ARSR-4 RMS shall be monitored and recorded at the LDC.

4.2.6.2.1 Failure Relevance Definitions

(a)   Relevant Failure: a failure which can be attributed, after failure analysis, to any of the following:

   (1)   Any maintenance action required to maintain full mission capability or the failure of the system to reconfigure automatically within 100 msec so as to maintain full mission capability.

   (2)   Hardware or software/firmware design defects.

   (3)   Manufacturing process, material or workmanship defects.

   (4)   Physical or functional deterioration (such as wear out, fatigue, or tolerance degradation).

   (5)   Failure of parts of known limited life (such as batteries) occurring prior to the end of the stipulated period.

   (6)   Intermittent failure.

   (7)   Failures due to incorrect instruction in the technical manuals used during the RVT.

   (8)   Any other failure that is not listed as a nonrelevant failure.

(b)   Nonrelevant Failures: a failure which can be attributed, after failure analysis, to any of the following:

(1)   Damage resulting from improper installation.

(2)   Failure of test instrumentation or monitoring equipment (other than the RMS) that is external to the test equipments under test.

(3)   Interrupted operation caused by external power failures.

(4)   Equipment failures caused by externally applied over stressed conditions in excess of the specified requirements.

(5)   Damage resulting from accident or mishandling by personnel performing the RVT.

(6)   Failures due to procedural errors by technicians or operators.

(7)   Dependent failure (i.e., a failure of a part(s) as a direct result of a failure of another part within the same LRU). It must be established by the contractor to the satisfaction of the Government that the failure(s) was dependent upon another part failing and was not an unrelated incident occurring at the same time.

(8)   Failure of certain parts (limited life parts) occurring after their known useful life has expired will not be counted as relevant if identified and approved by the government prior to start of the RVT.

4.2.5.2.2 Acceptance Criteria for Mission Reliability. - The observed MTBCF for 6000 contiguous hours of operation of the ARSR-4 system must be equal to or exceed 1500 hours (i.e., not more than 4 relevant critical failures) for full mission capability. Additionally, there shall be no critical failures to either the RMS or the antenna during this same 6000 hour period. In the event that these MTBCF requirements are not met in the first 6000 hours of operation, testing and failure corrective action will continue until the system matures to a current MTBCF of 1500 hours for a contiguous 6000 hour period, and the separate requirements for the RMS and antenna are met during the same 6000 hour period. Current MTBCF will be determined for each 1000 hours of operation by dividing the last 6000 hours of operation by the total relevant critical failures for that period of time. Shipment of production systems will not be permitted until the requirements of this paragraph have been met.

4.2.6.2.3 <u>Acceptance Criteria for Basic Reliability</u>. - The observed MTBF, for the same 6000 hours of operation for which the MTBCF was successfully demonstrated, must be 100 hours or greater. The MTBF shall be determined by dividing the 6000 hours of operation by the total number of ARSR-4 relevant failures. Shipment of production systems will not be permitted until the requirements of this paragraph are met.

4.2.6.3 <u>Thermal/Electrical Stress Tests</u>.- The contractor shall verify the thermal and electrical stresses on 5 percent (randomly selected by the Government) of the semiconductor and microcircuit parts by measurement while the equipment is operated at the worse case environment, duty cycle, and load. The results of the measurements shall be compared to the derating requirements, and the verification will be considered successful if measured values are equal to or less than specified.

4.2.7 <u>Maintainability Test and Evaluation</u>.- Maintainability requirements shall be verified in accordance with the following subparagraphs.

4.2.7.1 <u>Maintainability Analysis</u>.- The results of the final maintainability prediction for the ARSR-4 shall be compared to the quantitative requirements and successful achievement determined if the predicted parameters are less than or equal to the required parameters.

4.2.7.2 <u>Maintainability Demonstration</u>.- A maintainability demonstration shall be performed on the ARSR-4 in accordance with the SOW.

4.2.7.3 <u>Maintainability Demonstration Test Log</u>.- A chronological test log shall be maintained throughout the maintainability demonstration tests as specified in the SOW.

4.2.8 <u>Software Test Requirements</u>.- Software testing shall include all software provided under the contract. This shall include verification of the ARSR-4 PSF.

4.2.8.1 <u>Informal Software Testing</u>.- The contractor shall conduct informal software testing in accordance with the requirements of the SOW and in accordance with 4.2.8.1.1 and 4.2.8.1.2 herein for all software developed. Formal testing shall be conducted in accordance with 4.2.8.2. The Government shall have access to all test information and results.

4.2.8.1.1 Unit Tests.- Prior to start of qualification tests, the contractor shall conduct (informal) unit level and integration tests in accordance with DOD-STD-2167. For each unit, the contractor shall maintain a unit test folder which shall contain, as a minimum, a description of each specific ARSR-4 program functional/performance requirement designed into the unit, the objective of each test conducted, the test steps invoked, the test result(s), and the date each test was conducted. A minimum of 10% of the tests shall be witnessed by the contractor's quality assurance personnel, and these personnel shall affix an identification stamp on each test data sheet to indicate that the software tested satisfies its design requirements.

4.2.8.1.2 Functional String Test.- Prior to conducting formal tests, the contractor shall conduct (informal) tests of each functionally related string (e.g., path or threads) contained/defined within each computer program components. For each computer program component, the contractor shall maintain a test folder which shall contain, as a minimum, a description of the ARSR-4 program performance/functional requirement(s) designed into the computer program component, a description of each string contained therein, the objective of each test conducted, the test steps invoked, the test result(s), and the date each test was conducted. A minimum of 10% of the tests shall be witnessed by the contractor's quality assurance personnel, and these personnel shall affix an identification stamp on each test data sheet to indicate that the software tested satisfies its design requirements.

4.2.8.2 Formal Software Testing.- The contractor shall conduct formal software testing in accordance with the requirements of DOD-STD-2167 for all software developed, using Government approved software test plans and software test procedures identified in the SOW. The contractor shall document the results of formal software testing in software test reports identified in the SOW and submit the same to the Government for review and approval. The Government shall witness all formal software testing unless waived by the Government.

4.2.8.2.1 Formal Testing.- The contractor shall conduct formal testing for each CSCI in accordance with the requirements specified in the Government approved Software Requirements Specification and the Interface Requirements Specification identified in the SOW.

4.2.8.2.2 Hardware/Software Integration Testing.- Subsequent to Formal Qualification Test (FQT), the contractor shall conduct Hardware-Software Integration Testing in order to demonstrate to the maximum extent possible in the contractor's facility that the CSCIs, when integrated with the using Configuration Items (CIs), perform and meet the requirements of this specification.

4.2.8.2.3 Software Performance Qualification Testing.- Once the software is integrated with the hardware, a formal performance qualification test of the integrated software shall be performed and reviewed in accordance with DOD-STD-2167 and MIL-STD-1521. Test procedures and test reports shall be supplied as identified in the SOW. Software performance qualification testing shall be required for each software version delivered. Once a software version is qualified, additional systems using that version shall only require system acceptance testing. Tests shall exercise all algorithms in their final form and shall include throughput tests under processing load conditions varying from minimum to maximum.

4.2.9 Quality Verification Matrix for Phase I, In-Plant QT&E.- Compliance with the section 3 performance requirements identified in the Quality Verification Matrix in Table 4-1 shall be satisfactorily verified prior to the ARSR-4 being delivered to a field site.

4.2.10 24-Hour Continuous Operation Test.- After completion of all regular production tests, each radar shall be aligned, in accordance with the standard instruction manuals, to produce optimum performance and allowed to operate for a period of 24 continuous hours without readjustment. The 24-hour continuous operation test shall be performed to demonstrate compliance with specified requirements. During this test, all CFE must meet all system requirements without failure of hardware or software. Any failure shall require a rerun of this 24 hour test once the failure is remedied. At the end of this period the equipment shall meet all applicable specification requirements. This test shall be satisfactorily completed prior to the system's delivery to a field site.

4.2.11 Radome Materials Tests.- Specific radome material tests shall be performed as specified in the following subparagraphs.

4.2.11.1 Radome Flammability Test.- The radome material shall be tested to the requirements of Federal Aviation Regulation (FAR), Part 25.853b, using the test methods of Part 25 Appendix F, Part 1.

4.2.11.2 Radome Combustibility Test.- The radome material shall be tested to the requirements of Federal Aviation Regulation (FAR), Part 25.853b, using the test methods of Part 25 Appendix F, Part 1.

4.2.11.3 Radome Hydrophobic Surface Test.- The radome material shall be tested for its hydrophobic surface properties. The maximum surface free energy shall be 20 Ergs/cm^2.

Hydrophobicity measurements shall include the measurement of water contact angles as measured using a Kaness, Inc. Mode D-1060 or equivalent contact angle viewer.

4.2.11.4 Radome Water Absorption Test.- Radome wall samples shall be tested for each and all of its subunits by total immersion of sample(s) of wall subunits in water with sample edges unsealed. The samples, after 24 hours of total immersion, shall not have absorbed water; as determined by the weight of the sample not increasing more than one percent.

4.2.11.5 Radome Weathering Test.- Advanced weathering tests that conform to ASTM-G-53-84 shall be performed on radome materials.

4.2.11.6 Radome Environmental Test.- Environmental tests shall be performed in accordance with MIL-STD-810 environmental test methods.

4.2.11.7 Radome Electromagnetic Performance Analysis.- Electromagnetic performance analyses shall be performed to calculate the radome's affects on the Mode S parameters identified in 3.5.1.4.1 through 3.5.1.4.7. This analysis shall also demonstrate the radome's impact on ARSR-4 performance across the ARSR-4 operating frequency band.

4.2.11.8 Radome Seam/Joint Test.- Any seams or joints used to fasten radome panels together by gluing, heat welding, plastic bonding or other methods not utilizing mechanical fastenings such as bolts, must be subjected to tests which will confirm the ability of the seam or joint to withstand loads encountered in the specified environmental conditions, and over the specified lifetime of the radome.

4.2.11.9 Radome Electromagnetic Emissions Test.- Auxiliary equipment shall be tested to verify the Electromagnetic Compatibility requirements of section 3 using the test procedures identified in the SOW.

4.2.12 Interface Tests.- The contractor shall demonstrate that the ARSR-4 can interface and operate compatibly with the following:

SOCC
RSSF
ARTCC
FAA Technical Center
ATCBI-5
Mode S
RRWDS
RMMS
Modems
Mode 4 Computer (KIR-1B or KIR-1C) and Interface Device (KG-84C)

As many interfaces and functions shall be active for this test as facility operational requirements permit.

4.3 Phase II On-Site QT&E.- The Phase II On-site QT&E requirements for the ARSR-4 shall be performed by the contractor and the Government as required at a Government selected site. All test equipment to demonstrate ARSR-4 performance, remote performance monitoring, and all other maintenance tasks shall be provided by the contractor. The standard test equipment shall remain at the site for the duration of the tests. As a minimum, the following shall be accomplished.

(a) Production tests

(b) Items identified in the Quality Verification Matrix

(c) System coverage demonstration

(d) Operational subclutter visibility

(e) Cancellation of multiple time around targets and clutter

(f) Interface tests

(g) RMS

(h) Weather processing

(i) Electrical power

(j) Environmental characteristics

(k) 72-hour continuous operation field test

The contractor shall perform such additional inspections, analyses, demonstrations, and tests necessary to establish compliance with Table 4-1.

4.3.1 **Production Tests**.- The following listed test items, as a minimum, shall be performed on each ARSR-4 in order to demonstrate compliance with specified requirements.

Transmitter peak power
Pulsewidth
Average PRF
Noise figure
Receiver sensitivities
System stability
Capacity
RF pulse radiated spectrum
TR device, recovery time
STC RF plumbing, pressurization integrity
Trigger requirements
Clutter processing performance
Test target generator

RFG performance
Point of control
Alarm controls
Search target processing
Beacon target processing
Weather Channel
Five level weather
RMS
Mode 4 processing performance
Formatter performance
Automatic Ka insertion from the on-site weather station

4.3.2 **Quality Verification Matrix for Phase II, On-Site QT&E**.- Compliance with the section 3 performance requirements identified in the Quality Verification Matrix in Table 4-1 shall be satisfactorily verified prior to the ARSR-4 being accepted by the Government.

4.3.3 **System Coverage Verification**.- Flight testing, in accordance with the SOW, shall be accomplished prior to the ARSR-4 being accepted by the Government. This flight testing shall use a T-38 aircraft supplied by the Government. The contractor shall demonstrate the ARSR-4's capability to meet all the detection performance requirements of section 3.

The flight testing specified herein shall use a T-38 aircraft which shall be supplied by the Government. The T-38 has a RCS of $2.2m^2$ and shall be assumed as having Swerling I characteristics. Any other aircraft needed for performance verification shall be an aircraft mutually agreed upon by both the Government and the contractor.

4.3.4 **Operational Subclutter Visibility (SCV)**.- The contractor shall demonstrate that the operational SCV of the system meets the specified performance requirements of section 3 for live clutter and with the antenna beam rotating. The procedure to be used shall be in accordance with Appendix D of this specification. Blip/scan data shall be collected over ten scan intervals and recorded. This test shall be repeated ten times on seven consecutive days and then averaged to determine the operational SCV. The test shall be repeated over several velocities selected by the contractor and approved by the Government.

4.3.5 **Multiple Time Around Target/Clutter Cancellation**.- The contractor shall demonstrate the ARSR-4's ability to cancel multiple time around targets and clutter as specified in section 3.

4.3.6 Interface Tests.- The contractor shall demonstrate that the ARSR-4 can interface and operate compatibly with the following:

      SOCC
      RSSF
      ARTCC
      FAA Technical Center
      ATCBI-5
      Mode S
      RRWDS
      RMMS
      Modems
      Mode 4 Computer (KIR-1B or KIR-1C) and Interface Device (KG-84C)

As many interfaces and functions shall be active for this test as facility operational requirements permit.

4.3.7 Remote Monitoring Subsystem.- The contractor shall demonstrate the operation, ease of calibration, and effectiveness of the RMS. This shall include, but not be limited to, remote monitoring of ARSR-4 performance, diagnostics of the ARSR-4, field adjustable/selectable parameters/controls, and the compatibility of RMS test equipment for use during corrective maintenance.

4.3.8 Weather Processing.- The contractor shall demonstrate the operation and stability of the weather processing functions of section 3. This will include, but is not limited to the following:

(a)   A demonstration of the ability to accurately report the five weather thresholds corresponding to the standard NWS values.

(b)   A demonstration of readily interpreted weather contours, with the least amount of ambiguity between contour levels or boundaries, to demonstrate smoothing from scan to scan.

(c)   A demonstration of operator controls for operator selection of the three weather contour levels.

4.3.9 Electrical Power.- Total power consumption shall be measured at the service entrance for the complete ARSR-4 during the evaluation period to determine the energy efficiency and compatibility with the existing engine-generator and environmental subsystem of the site. Power interrupt/switching between commercial and engine-generator sources shall be evaluated to insure minimum disruption to the ARSR-4 in an operating environment per the requirements of this specification.

4.3.10 _Environmental Characteristics_.- The contractor shall demonstrate the ARSR-4 impact on the environmental characteristics at the site. This will include, but is not limited to, the following:

(a)   Interior building temperature control as affected by transmitter heat transfer and ventilation

(b)   General characteristics of heat transfer from electronic equipment cabinets

(c)   Interior and exterior noise levels shall be measured for comparative purposes and to insure that the noise level produced during normal system operation does not exceed limits specified in 3.8.1.8.

(d)   All ionizing and nonionizing radiation leakage levels.

4.3.11 _Continuous Operation Field Test_.- A 72-hour continuous operation field test shall be performed to demonstrate compliance with specified requirements. During this test, all CFE must meet all system requirements without failure of hardware or software. Any failure shall require a rerun of this 72 hour test once the failure is remedied. At the end of this period, the equipment shall meet all applicable specification requirements. This test shall be satisfactorily completed prior to Government acceptance.

4.4 _Phase III In-Plant PAT&E_.- Phase III is the in-plant quality assurance test for production of the ARSR-4 and applies to all systems provided by the contractor. As a minimum, the following shall be accomplished.

(a)   System and Subsystem Production Acceptance Test

(b)   Production Tests

(c)   Items identified in the Quality Verification Matrix

(d)   24-hour Continuous Operation Test

(e)   Type Test

The contractor shall perform such additional inspections, analyses, demonstrations, and tests necessary to establish compliance with the requirements listed in Table 4-1.

4.4.1 System and Subsystem Production Acceptance Test.- Each ARSR-4
delivered under the contract shall be completely wired and assembled in its
final installed configuration for the system production tests at the
contractor's manufacturing location. System production testing shall be
performed with the equipment fully assembled and operable and radiating as a
complete system. Antenna testing may be performed separately, if necessary;
however, an installed antenna complying with all performance requirements
specified herein shall be available for system testing.

In addition to appropriate mechanical and electrical tests, the contractor
shall generate a set of antenna radiation patterns on each antenna and its
associated equipment. The test shall be conducted on an antenna test range
meeting the requirements specified in Appendix E. Antenna testing during
Phase I shall be accomplished with the one beacon antenna mounted, with two
beacon antennas mounted, and without any beacon antenna(s) mounted as
specified in 3.5.2.1. At least three antenna patterns shall be generated for
each antenna produced, verifying all applicable requirements; such as antenna
beamwidth, antenna gain, cross polarization ratio, circular polarization
cancellation ratio (if applicable), the requirements of 3.5.2, etc. Each set
of patterns shall be taken at a discrete test frequency and pointing angle.
The set of frequencies and pointing angles used to test each individual
antenna shall be randomly selected and be unique to that antenna. The test
frequencies used shall be distributed across the low, middle, and upper part
of the operating band to assure that antenna pattern anomalies related to
frequency that are detrimental to system performance are not present. The
minimum separation between the test frequencies shall not be less than 25 MHz.

4.4.1.2 Production Tests.- The following listed tests, as a minimum, shall
be performed on each ARSR-4 to be delivered to the Government in order to
demonstrate compliance with specified requirements.

Transmitter peak power	RFG performance
Pulsewidth	Point of control
Average PRF	Alarm controls
Noise figure	Search target processing
Receiver sensitivities	Beacon target processing
System stability	Weather Channel
Capacity	Five level weather
RF pulse radiated spectrum	RMS
TR device, recovery time	Mode 4 processing performance
STC RF plumbing, pressurization integrity	Formatter performance
Trigger requirements	Automatic Ka insertion from
Clutter processing performance	the on-site weather station
Test target generator	

4.4.1.3 Quality Verification Matrix for Phase III In-Plant PAT&E.-
Compliance with the section 3 requirements identified in the Quality
Verification Matrix in Table 4-1 shall be satisfactorily verified prior to the
ARSR-4 being delivered to a field site.

4.4.1.4 24-Hour Continuous Operation Test.- After completion of all regular production tests, each radar shall be aligned, in accordance with the standard instruction manuals, to produce optimum performance and allowed to operate for a period of 24 continuous hours without readjustment. The 24-hour continuous operation test shall be performed to demonstrate compliance with specified requirements. During this test, all CFE must meet all system requirements without failure of hardware or software. Any failure shall require a rerun of this 24 hour test once the failure is remedied. At the end of this period the equipment shall meet all applicable specification requirements. This test shall be satisfactorily completed prior to the system's delivery to a field site.

4.4.2 Type Test.- The Phase III Type Test performed under the service conditions shall be performed in accordance with 4.3.3 of FAA-G-2100. The complete ARSR-4 design shall be tested under service conditions as specified in 4.11 of FAA-G-2100. Antenna type testing may be performed separately; however, the type test system shall be connected to an installed operating antenna so as to provide a true operating environment.

4.4.2.1 Type Test Requirements.- The contractor shall submit type test procedures and test data sheets for approval by the Government. As appropriate, system performance tests shall be made in all modes of operation while type testing. Since the radar design is not defined in this specification, a complete list of tests to be performed shall be submitted to the Government for approval.

4.5 Phase IV On-Site PAT&E.- Phase IV is the on-site quality assurance tests for the ARSR-4 and applies to all production systems. Some of the specific tests for this phase of testing shall be derived from previous (Phases I, II, III,) phases upon approval by the Government. As a minimum, the following shall be accomplished.

(a) Items identified in the Quality Verification Matrix

(b) System Coverage verification

(c) Operational SCV

(d) Multiple Time Around Target/Clutter Cancellation

(e) Interface Tests

(f)   RMS

(g)   Weather Processing

(h)   Electrical Power

(i)   Environmental Characteristics

(j)   Continuous operation Field Test

The contractor shall perform such additional inspections, analyses, demonstrations, and tests necessary to establish compliance with the requirements listed in Table 4-1.

4.5.1 Quality Verification Matrix for Phase IV.- Compliance with the section 3 requirements identified in the Quality Verification Matrix in Table 4-1 shall be satisfactorily verified prior to the ARSR-4 being accepted by the Government.

4.5.2 System Coverage Verification.- Flight testing, in accordance with the SOW, shall be accomplished prior to the ARSR-4 being accepted by the Government. This flight testing shall use a T-38 supplied by the Government. The contractor shall demonstrate the ARSR-4's capability to meet all the detection performance requirements of section 3.

The flight testing specified herein shall use a T-38 aircraft which shall be supplied by the Government. The T-38 has a RCS of $2.2m^2$ and shall be assumed as having Swerling I characteristics. Any other aircraft needed for performance verification shall be an aircraft mutually agreed upon by both the Government and the Contractor.

4.5.3 Operational Subclutter Visibility (SCV).- The contractor shall demonstrate that the operational SCV of the system meets the specified performance requirements of section 3 for live clutter and with the antenna beam rotating. The procedure to be used shall be in accordance with Appendix D of this specification. Blip/scan data shall be collected over ten scan intervals and recorded. This test shall be repeated ten times on seven consecutive days and then averaged to determine the operational SCV. The test shall be repeated over several velocities selected by the contractor and approved by the Government.

4.5.4 Multiple Time Around Target/Clutter Cancellation.- The contractor shall demonstrate the ARSR-4's ability to cancel multiple time around targets and clutter as specified in section 3.

4.5.5 Interface Tests.- The contractor shall demonstrate that the ARSR-4 can interface and operate compatibly with the following:

        SOCC
        ARTCC
        ATCBI-5
        Mode S
        RRWDS
        RMMS
        Modems
        Mode 4 Computer (KIR-1B or KIR-1C) and Interface Device (KG-84C)

As many interfaces and functions shall be active for this test as facility operational requirements permit.

4.5.6 Remote Monitoring Subsystem.- The contractor shall demonstrate the operation, ease of calibration, and effectiveness of the RMS. This shall include, but not be limited to, remote monitoring of ARSR-4 performance, diagnostics of the ARSR-4, field adjustable/selectable parameters/controls, and the compatibility of RMS test equipment for use during corrective maintenance.

4.5.7 Weather Processing.- The contractor shall demonstrate the operation and stability of the weather processing functions of section 3. This will include, but is not limited to the following:

    (a)   A demonstration of the ability to accurately report the five weather thresholds corresponding to the standard NWS values.

    (b)   A demonstration of readily interpreted weather contours, with the least amount of ambiguity between contour levels or boundaries, to demonstrate smoothing from scan to scan.

    (c)   A demonstration of operator controls for operator selection of the three weather contour levels.

4.5.8 Electrical Power.- ARSR-4 power consumption shall be measured at the service entrance for the complete ARSR-4 during the evaluation period to determine the energy efficiency and compatibility with existing engine-generator and environmental subsystem of the site. Power interrupt/switching between commercial and engine-generator sources shall be evaluated to insure minimum disruption to the system in an operating environment per the requirements of this specification.

4.5.9 Environmental Characteristics.- The contractor shall demonstrate the ARSR-4 impact on the environmental characteristics at the site. This shall include, but is not limited to, the following:

(a) Interior building temperature control as affected by transmitter heat transfer and ventilation

(b) General characteristics of heat transfer from electronic equipment cabinets

(c) Interior and exterior noise levels shall be measured for comparative purposes and to insure that the noise level produced during normal system operation does not exceed limits specified in 3.8.1.8.

(d) All ionizing and nonionizing radiation leakage levels.

4.5.10 Continuous Operation Field Test.- A 72-hour continuous operation field test shall be performed to demonstrate compliance with specified requirements. During this test, all CFE must meet all system requirements without failure of hardware or software. Any failure shall require a rerun of this 72 hour test once the failure is remedied. At the end of this period, the equipment shall meet all applicable specification requirements. This test shall be satisfactorily completed prior to Government acceptance.

4.6 Testing Methods.- The following subparagraphs describe the verification methods that shall be used in the Quality Verification Matrix in Table 4-1.

4.6.1 Inspection.- The success criterion for inspection shall be pass/fail.

4.6.1.1 Hardware.- Inspection of hardware is defined as a method of verification of physical characteristics that determines compliance without the use of special laboratory equipment, procedures, items, or services. Inspection is used to verify construction features, document and drawing compliance, workmanship, and physical condition.

4.6.1.2 Software.- Software examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, to determine compliance with requirements. This nondestructive examination includes review of software source and object listings to verify compliance with software documentation, requirements, and coding standards, as well as verification of the implementation of required mathematical equations.

4.6.2 Test.-

4.6.2.1 Hardware.-

Hardware test is defined as a method of verification wherein performance is measured during or after the controlled application of functional and/or environmental stimuli. Measurements require the use of laboratory equipment, procedures, items, and services.

4.6.2.2 Software.-

Software test is an activity that employs technical means; including evaluation of functional operation by use of special equipment or instrumentation, simulation techniques, and the application of established principles and procedures; to determine compliance with requirements. Test performance is the means of creating data for detailed analysis. The analysis of data derived from tests is an integral part of the activity.

4.6.3 Demonstration.-

Demonstrations are used to indicate "pass/fail" conditions.

4.6.3.1 Hardware.-

Hardware demonstration is defined as a method of verification denoting the qualitative determination of properties of an end-item or unit by observation. Demonstration is used without special test equipment or instruction to verify characteristics such as operational performance, human engineering features, service, access features, and transportability.

4.6.3.2 Software.-

Software demonstration is an activity that is limited to a readily observable functional operation to determine compliance with requirements (e.g., the proper response at a site as a result of a specified interrogation or command to be processed by the program). Demonstration is primarily used for activities where data gathering is not appropriate, such as CRT display verification.

4.6.4 Analysis.-

4.6.4.1 Hardware.- There are three methods of hardware analysis:

(a) Engineering Analysis. This type of analysis is usually an engineering design function. It involves the study, calculation, or modeling of the following:

  (1) Known or potential failure modes

  (2) Reactions or interactions of the specified parts, materials, and processes

  (3) The design configuration with the known function, performance, and/or probable effects of the operational environments

  This analysis is normally used to verify margin when it is not desirable to test to failure.

(b) Similarity analysis. Similarity analysis is a method applied to end-items or units that are identical in design and manufacturing processes to end-items or units that have been previously qualified to equivalent or more stringent requirements.

(c) Validation of records analysis. Validation of records analysis is a method of verification wherein manufacturing records are used as a method to verify compliance of concealed construction features or processes of manufacturing (e.g. vendor items).

4.6.4.2 Software.- Software Analysis is an activity taking the form of the processing of accumulated results and conclusions, intended to provide proof that the verification of a requirement(s) has been accomplished. The analytical results may be comprised of interpretation of existing information or derived from lower level tests, demonstrations, analyses or examinations.

TABLE 4-1, QUALITY VERIFICATION MATRIX

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
1.0	Scope	S				
3.1	Summary of Equipment and Services to be Furnished by the Contractor					
3.2	Not Used					
3.3	Definitions					
3.3.1	Principal Azimuth Plane					
3.3.2	Principal Elevation Plane					
3.3.3	Peak of Beam					
3.3.4	Nautical Mile (nm)					
3.3.5	High Sited Site					
3.3.6	Low Sited Site					
3.3.7	Reflectivity Factor (Z)					
3.3.8	Field Adjustable/Selectable					
3.3.9	Site Adjustable/Selectable					
3.3.10	Line Replaceable Unit (LRU)					
3.3.11	Site Visit					
3.3.12	Failure	S	ADT	DT		T
3.4	System Performance Requirements					
3.4.1	Primary Radar Coverage	C	A T	DT		DT
3.4.1.1	Search Coverage		A T	T		T
3.4.1.2	Search Detection Envelope	C	ADT	DT		DT
3.4.1.3	Height Coverage		A T	T		T
3.4.1.4	Height Detection Envelope					
3.4.1.5	Target Definition		A T	T	T	T
3.4.1.6	False Reports		ADT	DT		DT
3.4.1.7	Performance in Clutter	S			T	
3.4.1.8	Radar Target Capacity					
3.4.1.9	Primary Radar Accuracy		A T	T		
3.4.1.9.1	Range Accuracy		A T	T		
3.4.1.9.2	Azimuth Accuracy		A T	T		
3.4.1.9.3	Height Accuracy					
3.4.1.10	Primary Radar Resolution		A T	T		
3.4.1.10.1	Range Resolution		A T	T		
3.4.1.10.2	Azimuth Resolution		T			
3.4.1.11	Primary Radar Time Sidelobes		T	T		T
3.4.1.12	Primary Radar Data Update Rate		T	T		T
3.4.1.13	Primary Radar Split Probability	S				
3.4.1.14	System Data Delays					
3.4.1.15	Primary Radar Frequency	C	ADT	T		
3.4.1.15.1	Tunability		T		T	
3.4.1.15.2	Spectrum Engineering Criteria		D			
3.4.1.16	Primary Radar Jam Strobe Reporting	CS	T	DT	DT	D
3.4.1.17	Weather Data Output		D			
3.4.1.18	Remote Monitoring Subsystem (RMS)					

TABLE 4-1, QUALITY VERIFICATION MATRIX (continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			I A D T			
3.4.2	Beacon System Performance					
3.4.2.1	Transponder Replies					
3.4.2.2	ATCRBS Performance		T	T	T	T
3.4.2.3	Probability of Detection (Pd)	S			T	
3.4.2.4	Capacity		T	T	T	T
3.4.2.5	Range Resolution	C	T	T		
3.4.2.6	Azimuth Resolution		T	DT	T	T
3.4.2.7	Range Accuracy		T	T		T
3.4.2.8	Azimuth Accuracy		T	T	T	T
3.4.2.9	Split Reports		T	T	T	T
3.4.2.10	Code Validation and Accuracy		T	T	T	T
3.4.2.11	False Reports	S				
3.4.2.12	Fruit Rates	C				
3.4.2.13	Target Processor		DT	DT		D
3.4.2.14	Beacon Radar Equipment	S				
3.4.2.15	Mode 3/A and Mode C Mapping					
3.4.3	Availability/Reliability		AD			
3.4.3.1	Reliability Requirements		ADT			
3.4.3.1.1	Mission Reliability		A T			
3.4.3.1.2	Basic Reliability	S	DT			
3.4.3.1.3	Reliability Design Requirements		T			
3.4.3.1.3.1	Thermal Management and Derating					
3.4.3.1.4	Reliability Definitions		A			
3.4.3.1.5	Radome Reliability		A T			
3.4.3.2	Availability					
3.4.4	Maintainability		D	D		
3.4.4.1	Maintainability Quantitative Requirements		AD			
3.4.4.1.1	Corrective and Preventive Maintenance		AD			
3.4.4.2	Maintenance Actions		I D			
3.4.4.3	Maintainability Design		D			
3.4.4.4	Testability					
3.4.5	Useful Life					
3.4.6	Environmental Conditions					
3.4.6.1	Climatological		A T		T	
3.4.6.1.1	Ambient Temperature		A T		T	
3.4.6.1.2	Relative Humidity		A			
3.4.6.1.3	Altitude		I			
3.4.6.1.4	Rain		A			
3.4.6.1.5	Corrosive Salt Atmosphere		A			
3.4.6.1.6	Winds		I			
3.4.6.1.7	Fungus		A			
3.4.6.1.8	Snow and Ice Loading		T			
3.4.6.2	Electromagnetic Environment					

TABLE 4-1, QUALITY VERIFICATION MATRIX (Continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			A			
3.4.7	Transportability					
3.5	Functional Design Requirements		IADT			
3.5.1	Radome	I	D	D		D
3.5.1.1	Major Unit List					
3.5.1.2	Physical Characteristics		T			
3.5.1.2.1	Internal and External Surfaces		T	I		I
3.5.1.2.1.1	Water Penetration		T			
3.5.1.2.1.2	Hydrophobic Surface		T			
3.5.1.2.1.3	Protective Coating		T			
3.5.1.2.1.4	Solar Radiation		A T			
3.5.1.2.1.5	Ice and Snow Adhesion					
3.5.1.2.1.6	External Color		T			
3.5.1.2.2	Flammability and Combustibility		T			
3.5.1.2.3	Temperature Stability		A			
3.5.1.2.4	Physical Stability	I	T			
3.5.1.2.5	Snow Rope		A			
3.5.1.2.6	Aerodynamic Loading		A T			
3.5.1.2.7	Thermal Temperature Gradients	I				
3.5.1.2.8	Nameplates or Product Markings					
3.5.1.2.9	Radome Air Lock		IA			
3.5.1.2.10	Lightning Protection	S	IAD	I D		I D
3.5.1.2.11	Aircraft Obstruction Lights					
3.5.1.3	Auxiliary Equipment					
3.5.1.3.1	Remote Maintenance Monitoring		A			
3.5.1.4	Electrical Performance Requirements		A			
3.5.1.4.1	Antenna Main Lobe Beamwidth Error		A			
3.5.1.4.2	Boresight Error		A			
3.5.1.4.3	Boresight Error Slope		A			
3.5.1.4.4	Difference Pattern Null Depth Error		A			
3.5.1.4.5	Sidelobe Level Error		A			
3.5.1.4.6	Cross Polarization Ratio		A			
3.5.1.4.7	Transmission Loss	C	IADT		T	
3.5.2	Radar Antenna		IADT			
3.5.2.1	Beacon Antenna Provisions		A			
3.5.2.2	Antenna Alignment		ADT	D		
3.5.2.3	Mutual Interference		I D			
3.5.3	Pedestal	I	T		T	
3.5.3.1	Rotary Joint		T			
3.5.3.1.1	Phase Shift Tolerances		T		T	
3.5.3.2	Azimuth Pulse Generator (APG)		T	T		T
3.5.4	Transmitter		T			
3.5.4.1	Operating Frequency	I	DT	I		I
3.5.4.2	Transmitter Cooling					

TABLE 4-1, QUALITY VERIFICATION MATRIX (continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
3.5.4.3	Voltage Standing Wave Ratio (VSWR)		T			
3.5.4.4	Protective Circuitry					
3.5.5	Receiver	C	T	D		
3.5.5.1	Sensitivity Time Control (STC)		DT	D		
3.5.5.2	Receiver Video Output		T			
3.5.5.3	Receiver EMC		IA	D		D
3.5.5.4	Protective Circuitry		ADT	DT		DT
3.5.6	Clutter Processing		A T	T		T
3.5.6.1	Terrain Clutter		ADT	DT		DT
3.5.6.2	Weather Clutter		A	T		T
3.5.6.3	Sea Clutter		A	D		D
3.5.6.4	Anomalous Propagation (AP)		AD	D		D
3.5.6.5	Angel Clutter	C	T	T		
3.5.7	Search Target Extraction	C	A T	T		
3.5.8	Strobe Processing					
3.5.9	Beacon Target Processor					
3.5.9.1	Initial Functions		I T		D	
3.5.9.1.1	Target Processing		T			
3.5.9.1.2	Pulsewidth Discrimination	S	DT			
3.5.9.1.3	Bracket Detection		D			
3.5.9.1.4	Code Extraction		DT		DT	
3.5.9.1.5	Garble Sensing	C	I DT	T	T	D
3.5.9.1.6	BTP Timing	C	T		T	
3.5.9.1.7	Target Detection	C				
3.5.9.1.8	Code Validation	C				
3.5.9.1.9	Code Transformation	C				
3.5.9.1.10	Target Position Bias Correction	C	DT			
3.5.9.1.11	Runlength Processing	C	DT			
3.5.9.1.12	Strobe Processing	C	T			
3.5.9.1.13	Processing Range	C				
3.5.9.1.14	Beacon Offset	C				
3.5.9.1.15	Special Military Replies	CS	T		DT	
3.5.9.1.16	Target Message Content	C	T			
3.5.9.1.17	Mode Interlace Sequence	C		T	D	
3.5.10	Beacon/Search Reinforcement Function	C	A T	T		T
3.5.11	Scan to Scan Correlation	CS				
3.5.11.1	Editor	C	AD	D	D	D
3.5.12	Weather Data Subsystem		D			
3.5.12.1	Antenna Polarization		AD		D	
3.5.12.2	Weather Receiving Characteristics		DT	D	D	
3.5.12.2.1	Radar Remote Weather Display System (RRWDS) Output	C	DT	D	D	D
3.5.12.3	Weather Processor	C	A T	D		D
3.5.12.3.1	WP Ground Clutter Suppression					

TABLE 4-1, QUALITY VERIFICATION MATRIX (Continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			AD	D		D
3.5.12.3.2	Weather Averaging and Thresholding	C				
3.5.12.3.3	Weather Data Reporting	C				
3.5.12.3.3.1	Weather Range Discrimination	C				
3.5.12.3.3.2	Weather Contouring Range	C	T		D	
3.5.12.3.3.3	Weather Processor Output	S	I DT		D	
3.5.13	Output Interface Message Formatting	S	T		D	
3.5.13.1	Radar to SOCC Digital Radar Messages	S				
3.5.13.1.1	SOCC to Radar Request Messages	CS	T			
3.5.13.1.2	Military Message Output Buffer and Modem Control	CS		D	T	
3.5.13.2	FAA Message Formats	CS	T			
3.5.13.2.1	FAA Output Buffer and Modem Control					
3.5.13.3	Not Used					
3.5.13.4	Future Requirements		T	I		I
3.5.13.4.1	Additional Memory and Processing Capacity	C	DT		DT	
3.5.13.4.2	Future Message Contents					
3.5.13.4.3	Output Formats		D			
3.5.13.4.4	Future Configuration		I DT	I		I
3.5.13.5	Time of Year Clock	CS	D			
3.5.13.5.1	Time of Year Clock Buffered Outputs					
3.5.14	Not used		D			
3.5.15	Remote Monitor Subsystem (RMS)	CS	DT	T		T
3.5.15.1	Monitor and Alarm	S				
3.5.15.1.1	Operational Failure Alarms	S				
3.5.15.1.2	Pre-Alarms	S				
3.5.15.2	Remote Control	S				
3.5.15.3	Performance Certification	S	D	D		D
3.5.15.4	Diagnostics	CS	D	D		D
3.5.15.5	Remote Adjustments and Selection					
3.5.15.6	Not Used		T			
3.5.15.7	RMM Interfaces	S	I T			
3.5.15.7.1	Interface Control Document (ICD)	S	D	D		D
3.5.15.7.1.1	Portable Terminal Messages					
3.5.15.7.2	Interface Definition	S	D	D		D
3.5.15.8	Radar Remote Monitoring Subsystem (RMS)	S	I D			
3.5.15.8.1	RMS Processor	S	I ADT	DT		DT
3.5.15.8.2	On/Off-line Monitoring and Diagnostics		ADT	DT	DT	DT
3.5.15.8.3	Search Test Target Generator (STTG)		T	DT	T	D
3.5.15.8.3.1	Target Types	C	DT	D	D	D
3.5.15.8.3.2	Real Time Quality Control (RTQC) Targets		DT	D	DT	D
3.5.15.8.3.3	Strobe and Ring Targets	C	DT	DT	DT	DT
3.5.15.8.3.4	Weather Targets	S	T	DT	DT	DT
3.5.15.8.3.5	RF & IF Performance Monitoring Targets		T	T	T	D
3.5.15.8.3.6	Constant False Alarm Rate (CFAR) Test					

TABLE 4-1, QUALITY VERIFICATION MATRIX (continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			T			
3.5.15.8.4	Beacon Test Target Generator	C	DT		DT	
3.5.15.8.4.1	Beacon RTQC Target	S	DT		D	
3.5.15.8.4.2	Beacon Operational Test Targets		AD			
3.5.15.8.4.3	BTP Diagnostic Test	C	D			
3.5.15.8.5	Data Count Monitor	CS	I DT	DT	D	DT
3.5.15.8.6	Firmware Requirements					
3.5.15.8.7	Built-In Test Equipment (BITE)	S	T	DT		D
3.5.15.8.8	Report Mode	CS				
3.5.15.8.8.1	Alarm Reporting	CS				
3.5.15.8.8.1.1	Automatic Fault Alarm Reset	S				
3.5.15.8.8.2	Remote Monitor Subsystem (RMS) Status Reporting	S	ADT			
3.5.15.8.9	Remote Maintenance Monitoring (RMM) Diagnostics					
3.5.16	Local Display Console (LDC)		D	D		D
3.5.16.1	Plan Position Indicator (PPI)/Random Access PPI (RAPPI)		I DT	I D	I DT	I D
3.5.16.2	Console Requirements		T		T	
3.5.16.3	Range Selection		T		T	
3.5.16.3.1	Range Selection Offsetting		T		T	
3.5.16.4	Off-Centering		DT	D	DT	D
3.5.16.5	Electronic Cursor		DT	D	D	
3.5.16.6	Range Strobe		D		D	
3.5.16.7	Range Marks		D	D	D	
3.5.16.8	Video Inputs		I			
3.5.16.9	Writing Shelf		I D		I D	
3.5.16.10	Compass Rose		I D			
3.5.16.11	Implosion Shield		I D			
3.5.16.12	Physical Design		D			
3.5.16.13	Readout Inhibit		D		D	
3.5.16.14	Antenna Position Indicator		I DT	D	I DT	D
3.5.16.15	RAPPI Symbols		DT	D	D	D
3.5.16.16	RAPPI Refresh		IADT	D	I D	D
3.5.16.17	Printer		AD			
3.5.16.18	Data Entry Devices		DT	D	D	D
3.5.16.19	LDC Self-Test		DT	D	DT	D
3.5.16.20	PPI Display Self-Test		D	D	D	D
3.5.16.21	Tabular Display and Data Entry Device Test		I	T		
3.5.17	ARSR-4/ATCBI-5 Interface Requirements					
3.5.17.1	Input Video		D			
3.5.17.2	Beacon Mode Pair Triggers					
3.5.17.2.1	Mode 4 Requirements		T	D	D	
3.5.17.3	ATCBI Beacon Trigger Requirements		T	T	D	T
3.5.17.3.1	ATCBI Beacon Trigger Characteristics					
3.5.18	ARSR-4/Mode S Interface Requirements					
3.5.18.1	ARSR-4 Signal Target Extraction Function To Mode S	S	I	T		

TABLE 4-1, QUALITY VERIFICATION MATRIX (Continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
3.5.18.2	ARSR-4/Mode S Communications Interface Characteristics		T			
3.5.18.3	ARSR-4/Mode S Link Control Level					
3.5.18.3.1	Procedures	C				
3.5.18.3.2	Information Field	C	T			
3.5.18.3.3	Control Functions		A			
3.5.18.4	Message Level					
3.5.18.4.1	Code Set	C				
3.5.18.4.2	Message Format	C				
3.5.18.4.3	Target Report	C				
3.5.18.4.4	Status and Alarm Report	C				
3.5.18.5	Mode S Reinforcement Function to the ARSR-4 Editing Function Interface					
3.5.18.5.1	Physical Control Level		T		T	
3.5.18.5.1.1	Communication Links		T			
3.5.18.5.1.2	Communication Interface Characteristics					
3.5.18.5.2	Link Control Level	C				
3.5.18.5.2.1	Procedures	C				
3.5.18.5.3	Information Field					
3.5.18.5.4	Control Functions					
3.5.18.5.5	Message Level					
3.5.18.5.5.1	Code Set					
3.5.18.5.5.2	Message Format	CS	D			
3.5.18.6	Data Switch Requirements					
3.5.18.6.1	Mode 4 Data Switch Requirements			D		
3.5.18.7	Mark XV Requirements		T	T		D
3.5.18.8	Staggered Mode S Beacon Trigger		I T			
3.5.19	Radar Remote Weather Display System (RRWDS) Interface		T			
3.5.19.1	Weather Log Video		T			
3.5.19.2	Pretrigger		T	T		
3.5.19.3	Azimuth Reference Pulse (ARP)/Azimuth Change Pulse (ACP)					
3.5.19.4	Status Signal					
3.5.19.5	Optional Video Interfaces		DT			
3.5.20	Mode 4 Interface					
3.5.20.1	Mode 4 Peculiar External Interface Equipment		T	D		
3.5.20.2	Mode 4 Performance Requirements		T	DT		D
3.5.20.2.1	Mode 4 Requirements		T	D		D
3.5.20.2.2	Code Validation		T	D	T	D
3.5.20.2.3	Mode 4 Azimuth Resolution		DT	D	DT	D
3.5.20.3	Mode 4 Detailed Performance and Design Requirements	S	DT	DT		DT
3.5.20.3.1	Mode 4 Enabling	S	D	D	D	D
3.5.20.3.1.1	Enabling Functions at the SOCC	S	D	D		D
3.5.20.3.1.2	Enabling the Mode 4 at the ARSR-4 Site	S	D	D		
3.5.20.3.1.3	Sector Operation of Mode 4	S	DT	DT		T
3.5.20.3.1.3.1	Mode 4 Sector Enabling					

TABLE 4-1, QUALITY VERIFICATION MATRIX (continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
		CS	D	D		
3.5.20.3.1.3.2	Mode 4 Provisions for Operational Regulations		A D	D		
3.5.20.3.1.4	Enabling Mode 4 Mode 2, 3/A, and C		T	T		DT
3.5.20.3.1.4.1	Synchronization		T	T		
3.5.20.3.1.4.2	PRF		D	D		
3.5.20.3.1.4.3	Mode 4 Pretrigger Jitter					
3.5.20.3.1.4.4	ATCRBS SIF Interrogation					
3.5.20.3.1.4.5	Not Used					
3.5.20.3.1.4.6	Not Used		DT	DT		DT
3.5.20.3.1.4.7	Mode 4 Challenge Signal		T	T		T
3.5.20.3.1.4.8	Mode 4 Integrated Sidelobe Suppression (ISLS)		T	T		T
3.5.20.3.1.4.9	Mode 4 Gain Time Control (GTC) Trigger		T	T		T
3.5.20.3.1.4.10	Mode 4 Video Suppression Gate		T	T		T
3.5.20.3.1.4.11	Noise Jitter PRF		D	D	D	
3.5.20.3.1.4.12	Internal Trigger		T	T		
3.5.20.3.1.4.13	Mode 4 Pretrigger		T	T		T
3.5.20.3.1.4.14	Super Mode Pretrigger Signal		T	T		T
3.5.20.3.1.4.15	Readout Delay		DT	DT	D	T
3.5.20.3.1.4.16	Mode 4 Mode Switch		DT	DT	D	DT
3.5.20.3.1.5	Mode 4 Loop Test and Self Tests	CS	DT	DT		DT
3.5.20.3.2	Mode 4 Processing Requirements	S	D	D	D	D
3.5.20.3.2.1	Mode 4 Processor Functions		DT	D	DT	D
3.5.20.3.2.1.1	Isolate Mode 4 Output		T	D	D	
3.5.20.3.2.1.2	Mode 4 Designator	S	D			
3.5.20.3.2.1.3	Mode 4 Synchronizer					
3.5.20.3.2.1.3.1	Not Used					
3.5.20.3.2.1.3.2	Not Used					
3.5.20.3.2.1.3.3	Not Used					
3.5.20.3.2.1.3.4	Not Used	CS	I T	D		
3.5.20.3.2.2	Mode 4 Evaluation	C	T	D		D
3.5.20.3.2.2.1	Mode 4 Friend Level Decision	C				
3.5.20.3.2.2.2	Mode 4 Thresholding					
3.5.20.3.2.3	KIR-1B/KIR-1C Functions					
3.5.20.3.2.4	Interface Equipment Function	S	T			
3.5.20.3.2.4.1	General	S	DT	DT		DT
3.5.20.3.2.4.2	Detailed Requirements		T	DT		DT
3.5.20.4	Mode 4 Interface Function	S	DT	D		D
3.5.20.4.1	Interface Block Diagrams		I D	I D		I D
3.5.20.5	Physical Location of Mode 4 Subassemblies		I D	I	I	I
3.5.20.6	Mark XII Operating Controls		I			
3.5.20.7	Equipment and Cabling Connectors		T			
3.5.21	Remote Maintenance Monitoring (RMS) Interface		T			
3.5.22	Modem Interface Requirements		T			

TABLE 4-1, QUALITY VERIFICATION MATRIX (Continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
3.5.23	Not Used					
3.5.24	Automatic Refraction Correction for Radar Height Processing	CS	DT	D	T	
3.5.24.1	Weather Station	CS	D	D		
3.5.25	Data Extraction Subsystem	CS	DT			
3.5.25.1	Data Categories	CS	I T	T		T
3.5.25.2	Data Reduction	C				
3.5.25.2.1	Quick-Look Data Processing	C				
3.5.25.2.2	Extended Data Processing	C				
3.5.25.3	Extraction Equipment	CS	DT	I D		I D
3.5.26	ARSR-4 Start-Up					
3.5.26.1	Definition and Purpose		D	D	D	D
3.5.26.2	Initialization of System		T	T	T	T
3.5.26.3	System Recovery		T			
3.5.26.4	Computer Software Loading	C				
3.5.27	Site Operational Software	C		D		
3.5.27.1	ARSR-4 Site/Field Adjustable Parameters	CS	D	D		
3.6	Primary Power Requirements		D	D		D
3.6.1	Prevention of Date Loss		DT	D		D
3.6.1.1	Power Variations		D			
3.6.1.2	Transient Protection	I				
3.6.1.3	Power Consumption					
3.6.1.4	Input AC Line Controls	I	D			
3.7	Data Processor Architecture	I	T			
3.8	Physical and Electrical Characteristics					
3.8.1	Packaging and Construction	I				
3.8.1.1	Use of Existing Towers					
3.8.1.2	Modules	I				
3.8.1.2.1	Modular Concept	I				
3.8.1.2.2	Plug-in LRUs	I				
3.8.1.2.2.1	LRU Removal and Insertion Damage		D			
3.8.1.2.2.2	Induced Transients	I		I		I
3.8.1.2.3	LRU Card Extenders	I				
3.8.1.2.4	Mounting	I	D			
3.8.1.2.5	Connectors	I				
3.8.1.2.6	Interlocks	I				
3.8.1.3	Design and Construction	I				
3.8.1.3.1	Corrosion Control					
3.8.1.3.2	Materials and Finishes	I				
3.8.1.3.3	Equipment Surface Painting	I	D			
3.8.1.4	Cabinet Design	I	D			
3.8.1.4.1	Overheat Warning Devices	I	D			
3.8.1.4.2	Cabinet Illumination	I				
3.8.1.4.3	Front Panel Connectors and Cables					

TABLE 4-1, QUALITY VERIFICATION MATRIX (continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			I D	I		I
3.8.1.4.4	Shorting Rods					
3.8.1.4.5	Large Units		I			
3.8.1.4.6	Indicator Lights		I			
3.8.1.5	Ventilation, Heating, and Cooling Equipment		I			
3.8.1.5.1	Ventilation Blowers		I			
3.8.1.5.2	Air Filters					
3.8.1.6	Not Used		AD			
3.8.1.7	Safety		I			
3.8.1.7.1	Electromagnetic Radiation (EMR)		IA			
3.8.1.8	Human Performance/Human Engineering		D			
3.8.1.8.1	Access for Maintenance		I			
3.8.1.9	Workmanship		I			
3.8.1.10	Interchangeability		I D			
3.8.1.11	Nameplates and Product Marking		I			
3.8.1.12	Test Points		I			
3.8.1.13	Wire Identification		I			
3.8.1.14	Printed Circuit Cards		IAD			
3.8.1.14.1	Circuit Card Assemblies		I			
3.8.1.14.2	Unit Mounting		I			
3.8.1.14.3	Circuit Card Assembly Modification		I			
3.8.1.14.4	Printed Circuit Card Baseboard		I			
3.8.1.14.5	Solderless Wrapped Electrical Connectors		IA			
3.8.1.14.6	Printed Circuit Card Connectors					
3.8.1.14.7	Circuit Card Assembly Test Points		I D			
3.8.1.15	Controls		I			
3.8.1.15.1	Location of Controls					
3.8.1.16	Unit Requirements		IA T			
3.8.1.16.1	Semiconductors		I			
3.8.1.16.1.1	Semiconductor Terminal Identification		I			
3.8.1.16.2	Microcircuits		A			
3.8.1.16.2.1	Integrated Circuits		I			
3.8.1.16.2.2	Sockets for Microelectronic Devices					
3.8.1.16.3	Critical Parts		I			
3.8.1.16.4	Nonaxial-Leaded Parts		I			
3.8.1.16.5	Relays		I			
3.8.1.16.6	Transformers		I			
3.8.1.16.6.1	Transformers, Inductors, and Coils		I			
3.8.1.16.7	Batteries		I			
3.8.1.16.8	Electrical Filters					
3.8.1.16.9	Ferrous Materials					
3.8.2	Electrical Requirements		I			
3.8.2.1	Transient Protection		I			
3.8.2.1.1	Surge Protection		I			

TABLE 4-1, QUALITY VERIFICATION MATRIX (Continued)

Paragraph No.	Title	CS	PH 1	PH 2	PH 3	PH 4
			T			
3.8.2.2	Ripple Voltage		I			
3.8.2.3	System Grounding Requirements		I	I		I
3.8.2.3.1	Grounding Practices		I	I		I
3.8.2.3.2	System Grounding		T			
3.8.2.4	Power Supply Protection		I T			
3.8.2.4.1	Load Protection		I T			
3.8.2.4.2	Regulation		I DT			
3.8.2.4.3	Power Supply Indicators		I T			
3.8.2.4.4	Power Supply Metering		T			
3.8.2.5	Electromagnetic Interference and Susceptibility					
3.8.2.6	Electrostatic Sensitive Parts					
3.9	Maintenance and Logistics					
3.9.1	Maintenance Concept					
3.9.1.1	Site Level Maintenance					
3.9.1.2	Work Center Level Maintenance					
3.9.1.3	Depot Level Maintenance					
3.9.2	Logistics					
3.9.2.1	Support and Test Equipment					
3.9.2.1.1	System Level Test Equipment					
3.9.2.2	Parts Selection					
3.9.2.3	Personnel					
3.9.2.3.1	Maintenance Personnel					
3.10	ARSR-4 Program Support Facility (PSF)		D	D		
3.10.1	Processors	C				
3.10.2	Software Tools		I D	I D		
3.10.3	Input/Output Hardware					
3.11	Computer Software	C		I		I
3.11.1	Development Planning					
3.11.2	Software Architecture					
3.11.2.1	Unit Attributes					
3.11.2.2	Design Representation					
3.11.2.3	Software Documentation & Implementation					
3.11.2.4	Code Representation					
3.11.3	Special Tools, Standards and Techniques					
3.11.4	Not Used	S				
3.11.5	Software Reliability Design Features					
3.11.6	Software Maintainability					
3.11.7	Firmware					
3.11.8	Microprogramming					
3.11.9	Computer Programs for Microprocessor	S				
3.11.10	Software Spare					

General Notes to Table 4-1

NOTE 1: The contractor shall perform such additional inspections, analyses, demonstrations, and tests as necessary to verify full compliance of the ARSR-4 system with the specification requirements herein.

NOTE 2: Where multiple requirements are contained in a single paragraph or subparagraph, verification of all the individual requirements within that paragraph or subparagraph shall be required.

NOTE 3: The contractor shall substitute "Test" for "Demonstration" if required to verify specification compliance. Any other changes to the verification method specified in Table 4-1 shall require Government approval.

NOTE 4: Definitions:

C = Computer Software Configuration Item (CSCI)
 Formal Qualification Test (FQT)
S = Software Performance Qualification Test (SPQT)
PH 1 = Phase I, In Plant QT&E
PH 2 = Phase II, On-Site QT&E
PH 3 = Phase III, In-Plant PAT&E
PH 4 = Phase IV, On-Site PAT&E
I = Inspection
A = Acceptance
D = Demonstration
T = Test

APPENDIX A

RADAR CLUTTER MODEL

1.0 Scope - This clutter model is to be used for the simulation of a search radar clutter environment. It will be used in the calculation of system performance as defined in the specification and will be a criterion for the evaluation of the proposed designs. The distributed clutter sources defined in the model are terrain, sea, and weather. The point clutter or discrete sources modeled represent manmade land structures, ships and buoys on the sea surface, angels (birds and insects) and vehicles. The impact of anomalous propagation on clutter statistics is also presented. The models are applicable for L-Band (1.2 to 1.4 Ghz.) systems having resolution cells with at least one dimension (either downrange or crossrange) exceeding 500 feet, areas exceeding 50,000 square feet, and volumes exceeding 26 million cubic feet.

Three hypothetical sites form the foundation for applying the clutter models. The Lowland site (Figure Al-a) contains the heavily vegetated lowland terrain and sea environments. The radar antenna in the Low site is placed at 350 feet above mean sea level (MSL) with the local terrain at a nominal height of 100 feet MSL. Two High sites are defined. The first (Figure Al-b) is located in the midst of wooded hills with peaks up to 5000 feet MSL in elevation, mountain peaks exceeding 10,000 feet MSL and valley floors as low as 1000 feet. The radar antenna height at this site is 3500 feet. The second High site (Figure Al-c) is located on the border between a mountain and a lowland region and overlooks the sea. In this case, radar antenna is at 6500 MSL. Typical screening angles at these sites are less than 0.5 degrees. The maximum screening angle in any random configuration of these sites is 3.0 degrees.

The models present the physical locations and intrinsic characteristics of the scatterers. The values given in the following sections for distributed and discrete land clutter, distributed sea clutter, and vehicles inherently include local multipath and small-scale shadowing effects. For the ships and buoys on the surface of the sea and the scatterers above the surface (birds and weather as well as aircraft), multipath is not included in the given values and must be accounted for separately. The forward scatter coefficients and multipath formulas which are a function of wavelength, grazing angle, and surface characteristics, are defined in Table All for the sea surfaces. The received echoes will be obtained by the convolution of the modeled environment with the waveforms and antenna patterns of the proposed radar. Contaminations by the system instabilities and nonlinearities are not incorporated in the models. A list of the symbols used in this model are given in Table Al2.

2.0 Definition of Clutter Model Parameters - All distributed clutter types are modeled as a nonstationary process [1],[2],[3],[4],[9],[11],[12]. The backscatter from resolution cells containing distributed clutter is characterized by their reflectivity, also called effective normalized radar cross section. For volume clutter, the reflectivity n_v is defined as the effective radar cross section (RCS) from that cell divided by the resolution cell's volume. For the case where the scatterers form a surface, the reflectivity σ_0 is obtained by dividing the RCS by the projected area of the resolution cell's volume on the scattering surface. In this model, both n and σ_0 have similar intrinsic statistical properties. To introduce these properties, the following discussion will use a generalized reflectivity term

z to represent the instantaneous reflectivity given that the cell has a mean reflectivity u. It is understood that z and u represent, respectively, n_V and $\overline{n_V}$ for volume clutter and σ_0 and $\overline{\sigma_0}$ for areal clutter.

The mean reflectivity value of an elemental volume of distributed clutter located at R_i' at time t_1 is a random variable $\mathbf{u}_1 = \mathbf{u}_1(t_1, R_i')$ that can be estimated by averaging the instantaneous reflectivity values $z(t_1, w_h, R)$ for m carrier frequencies uniformly distributed between 1.2 to 1.4 Ghz.

$$u_1(t_1, R_i') = \frac{1}{m} \sum_{h=1}^{h=m} z(t_1, w_h, R_i')$$

where w_h represents carrier frequency h, and R_i' represents the location (R_a, θ_b, ϕ_c). Since the scatterers at different locations R_i', $i = 1, 2, \ldots$ can be of various quantities or sizes, u_1 can take on a wide range of values represented by a spatial amplitude density function $p_1(u_1)$. For a given resolution cell, the mean reflectivity is given by u_K where k denotes the average number of samples of u_1 are contained within the cell.

For volume scatterers, such as rain which consists of very small scatterers, u_1 is a function of the average scatterer density per unit volume and the variations in the scatterer size where both factors are assumed to vary slowly with R_i'. The correlation lengths D_r, and D_a define an elemental volume and denote the respective intervals in the range or cross range and altitude at which the reflectivity of an adjacent elemental volume assumes an uncorrelated sample of u_1. Within the elemental volumes, the mean values of smaller volumes are correlated as given by $d(\Delta \ell)$ (See Table A8). Therefore, every resolution cell with rain clutter will contain at least one sample of u within its volume, i.e., $k > 1$.

For land, which is modeled as a surface scatterer (even though it contains both surface and volume scatterers), u_1 is related to changes in average density and size of the scatterers as well as the average surface slope within an elemental volume. Since the resolution cells will have a cross range dimension ranging from over 500 feet at 5 nm. to over 18,000 feet at 180 nm, a simple model is used for land clutter where D_r, the radius of circular elemental areas, reflects the correlation properties of the terrain's large scale roughness and small scale roughness is ignored. Like rain, the mean values of smaller areas within an elemental area are correlated and k has values equal to or exceeding one.

For the sea, which is modeled as a surface scatterer, u_1 is related to the average surface slope within a resolution cell where the subscript k denotes the average number of elemental areas within the resolution cell. The waves of the sea are assumed to travel in the same direction as the environmental wind and D_u, the correlation length in the up/down wind directions, corresponds to the distance between "effective" water wavelengths W. For horizontal polarization, W is assumed to be the average water wavelength of gravity waves. For vertical polarization, W is assumed to be a much shorter length related to the average distance between smaller developing waves and between regions of spray and foam. For simplicity, the dimension of an elemental area in the cross wind direction D_c is assumed to be the size of the resolution cell. The smaller scale correlation properties which would reflect the effects of the different slopes, or even shadows, between the gravity waves are ignored. Therefore, k has values equal to or exceeding one.

For resolution volumes with dimensions that are larger than one or more of the correlation lengths, the mean reflectivity of the larger cell u_k represents the sum of the RCS from k elemental units (volumes, areas, or water wavelengths) normalized by the sum of the units. In essence, this is a noncoherent averaging process where the mean value in each resolution cell represents an estimate of η_μ the expected value of u_k,

$$\eta_\mu = E\{u_k\} = \int_0^\infty u_k p_k(u_k)\, du_k = \int_0^\infty u_l p_l(u_l)\, du_l$$

Adjacent cells represent uncorrelated samples of u_k which has a density function $p_k(u_k)$. The density function $p_k(u_k)$ is centered around the same expected value η_μ but is narrower and less skewed than $p_l(u_l)$. Thus, for very large cells containing large k (for example, the volume occupied by the uncompressed pulse length and antenna pattern at long range), $p_k(u_k)$ can be approximated by η_μ for all but the most skewed density functions $p_l(u_l)$.

The spatial arrangement of distributed clutter scatterers is uniformly distributed within each resolution cell and random from cell to cell. Therefore, the instantaneous reflectivity z of a resolution cell at location R_l with mean reflectivity $u_k = u$ at time t_l will vary around u when observed with different carrier frequencies. This instantaneous reflectivity $z(w) = z(t_l, w, R_l)$ is a random variable that has a frequency fluctuation density function $p(z(w)/u_k=u)$. In this model, $z(w)$ is proportional to χ^2 where χ is a complex zero-mean Gaussian random variable. Therefore, $p(z(w)/u_k=u)$ is exponential for all distributed clutter types. Uncorrelated samples of z can be obtained by sampling at carrier frequency intervals equal to the waveform bandwidth.

The scatterers can be either randomly moving, stationary, or a combination of the two. If the cell of mean $u_k = u$ contains many randomly moving scatterers where (1) the phase of each scatterer is varies randomly over +/- 180 degrees and (2) the amplitude and phase received from scatterer i is independent of the amplitude and phase received from any other scatterer j, then $z(t, w_h, R_l)$ is a random variable that follows a temporal fluctuation density function $p(z(t)/u_k=u)$. In this case, $p(z(t)/u_k=u)$ will be of the same form as $p(z(w)/u_k=u)$, i.e. exponential. Information on the rate of fluctuation is contained in the spectral density function S(f) or autocorrelation function $R(\tau)$. Uncorrelated samples can be obtained at time intervals where $R(\tau)$ is approximately zero.

If the cell at R_l contains only distributed stationary scatters with mean $u_k = u$, the instantaneous value $z(t, w_h, R_l)$ from that cell when observed using a single carrier frequency w_h will be a single value sampled from z for all time t. The class of moving scatterers that do not satisfy both conditions (1) and (2) given above (i.e., tree trunks or buildings that slowly sway less than one quarter of a carrier wavelength in the presence of wind) represent an intermediate condition or quasi-stationary case and, for the purposes of this model, are represented as stationary scatterers. For terrain clutter which has large stationary scatterers as well as moving scatterers, the frequency and temporal fluctuation density functions $p(z(w)/u_k=u)$ and $p(z(t)/u_k=u)$ generally have different forms. Furthermore, the relative population of stationary and moving scatterers within a cell depends on the wind speed and is described in this model by a DC-to-AC power ratio, m^2.

Terrain clutter scatterers do not move from one resolution cell

to another and the number and size of scatterers within a cell remain constant. In this case, $u_K(t_1,R_i) = u(t_2,R_i)$ for all times t_1 and t_2. However, for moving clutter such as sea or weather, a group of scatterers can move through a resolution cell in tens of seconds, causing the cell's mean value to change with time. In this case, the mean reflectivity of a cell $u_K(t) = u_K(t,R_i)$ is a random variable that is also a function of time. The instantaneous reflectivity $z(t) = z(t,w_h,R_i)$ of a cell at R_i when observed using a single carrier frequency w_h will have the density function given by equation (A1a).

(A1a)
$$p(z(t)) = \int_0^\infty p(z(t)/u_K(t)=u) \, p(u) \, du$$

When samples of $z(t)$ are taken over a sufficiently short interval of time between t_1 and t_2 such that $u_K(t) = u_K(t_1)$ for all t between t_1 and t_2, then $p(u)$ can be replaced by an impulse at $u_K(t_1)$ and $p(z(t)) = p(z(t)/u_K(t_1))$. When samples of $z(t)$ are taken over longer intervals of time such that the mean reflectivity of the cell assumes two or more uncorrelated samples of u_K, then $p(u)$ is equal to the $p_K(u_K)$. Therefore, the appropriate form of $p(z(t))$ depends on the interval of time over which the detection or other process is being performed as well as the velocity and statistics of the clutter type and the size of the resolution cell.

Some detection processes may use samples of reflectivity at different locations R_i requiring knowledge of $z(R_i) = z(t_1,w_h,R_i)$ which will have a density function $p(z(R_i))$ as given in equation (A1b).

(A1b)
$$p(z(R_i)) = \int_0^\infty p(z(R_i)/u_K(R_i)=u) \, p(u) \, du$$

When samples of $z(R_i)$ are taken over a sufficiently short interval of distance between R1 and R2 such that $u_K(R_i) = u_K(R1)$ for all R_i between R1 and R2, then $p(u)$ can be replaced by an impulse at $u_K(R1)$ and $p(z(R_i)) = p(z(R_i)/u_K(R1))$. When samples of $z(R_i)$ are taken over longer intervals of distance such that the mean reflectivity of the cells assume two or more uncorrelated samples of u_K, then $p(u)$ is equal to the $p_K(u_K)$ and $p(z(R_i))$ must be obtained through equation (A1b). When $p(z(R_i))$ is a function of $p_K(u_K)$, it is also a function of the resolution cell size. As noted previously, $p_K(u_K)$ narrows as k increases. As k approaches infinity, $p_K(u_K)$ approaches an impulse at η_u the expected value of u and $p(z(R_i))$ approaches $p(z(R)/\eta_u)$, an exponential density function, illustrating the well known Central Limit Theorem.

Point clutter or discretes are defined to be large complex scatterers that occupy an area or volume that is always much smaller than a resolution cell. The magnitude of point clutter is defined by a mean cross section $RCS(R_i)$ that can be estimated by averaging the instantaneous cross section $rcs(t,w,R_i)$ over m carrier frequencies uniformly distributed between 1.2 and 1.4 Ghz. The mean value of a discrete is a single value for all time. For a discrete with mean $RCS(R_i) = RCS$ at R_i, $rcs(w) = rcs(t_1,w,R_i)$ follows an exponential density function and $rcs(t) = rcs(t,w_h,R_i)$ follows a Rician density function. Information on the rate of fluctuation is given by S(f) or $R(\tau)$.

3.0 Clutter Types

3.1 Terrain Clutter - The terrain clutter environments are presented using areas or patches of distributed backscatter, point clutter, and shadowed regions where the backscatter is dominated by system noise. The amplitude of the point clutter is characterized by the effective radar cross section (RCS). The amplitude of the distributed clutter is characterized by the effective normalized radar cross section σ_0, which is defined as the effective radar cross section (RCS) of a resolution cell divided by the area (A) of the resolution cell.

(A2)
$$\sigma_0 = (RCS)/A$$

(A3)
$$A = R\,\theta\,(c\tau/2) \quad (\text{pulse limited case})$$

where R is the radar range to the resolution cell, θ is the 3 dB two-way azimuthal beamwidth of the radar aperture, c is the speed of light, and τ is the radar pulse length. For both distributed and point surface clutter, the effects of multipath, diffraction, and other local propagation effects existing under normal propagation conditions are included in the term effective radar cross section (RCS). Anomalous propagation conditions are discussed in Section A6.

The terrain environment is defined by three terrain classes represented in the three generalized sites: Lowland, Wooded Hills, and Mountains. The amplitude of the distributed clutter from Lowland terrain varies as a function of local grazing angle and is defined to exist out to the radar horizon. While Lowland terrain typically contains various manmade structures and extensive vegetation, it is nominally flat such that, under normal propagation conditions, the local grazing angle is calculated using a 4/3 equivalent earth radius propagation model. Under normal propagation conditions, point clutter scatterers are visible within a radius equal to the radar horizon plus 12 nm and are uniformly distributed within this radius. The average density of this point clutter in the Lowland terrain is 1 scatter per 30 square nautical miles.

Within the Wooded Hills terrain, 50% of the range-azimuth cells within a 100 nm radius are either dominated by thermal noise or contain one of the 50 uniformly distributed discretes. The remaining range-azimuth cells within 100 nm contain distributed clutter which is defined by patches with the sizes and numbers given in Table A2. The clutter patches are distributed uniformly in azimuth and follows a truncated exponential distribution in range within the following constraints:
      (a) the mean of the range distribution is 45.9 nm;
      (b) of the range-azimuth cells occupied by clutter patches within 100nm, 39.8% are contained within 20 nm (See Table A2);
      (c) the distribution of clutter patches in range is normalized to the number of patches given within 180 nm (See Table A2).

Similarly, within the Mountainous terrain, 60% of the range-azimuth cells within 100 nm are either dominated by system noise or contain one of the 50 uniformly distributed discretes. The remaining range-azimuth cells contains distributed clutter patches with the sizes and numbers given in Table A2. These patches are distributed uniformly in azimuth and follows a truncated

exponential distribution in range within the following constraints:
        (a) the mean of the range distribution is 37.8 nm;
        (b) of the range-azimuth cells occupied by clutter within 100 nm,
26.8% is contained within 10.8 nm;
        (c) the distribution of clutter patches in range is normalized to
the number of patches given within 180 nm.(See Table A2). Clutter from
scatterers beyond 180 nm are assumed to have levels well below the noise level
and are not detectable.

The spatial amplitude distribution functions $p_1(\overline{\sigma_{o1}})$ defining the range
of mean reflectivity values for the distributed clutter areas are Weibull
distributions with the parameters given in Table Al. Examples of these
distributions are provided in Figure A2. Conditional densities
$p(\overline{\sigma_o}(R_i)/\overline{\sigma_{oK}}=\overline{\sigma_{oe}})$ and $p(\overline{\sigma_o}(w)/\overline{\sigma_{oK}}=\overline{\sigma_{oe}})$ are exponential. Therefore, $p(\overline{\sigma_o}(t))$
and $p(\overline{\sigma_o}(R_i))$ can be obtained through equations (Ala) and (Alb), respectively.
The mean RCS values of the point clutter is also given in Table Al.

A terrain clutter cell is assumed to have both stationary and moving
scatterers, each contributing a portion of the total backscatter power.
Therefore, the backscatter from each terrain class is defined to have
intrinsic spectral density and autocorrelation functions containing "DC" and
"AC" components. These functions, given in Table A3 and plotted in Figures
A3a and A3b, have been normalized such that the total energy is unity. The
"DC" component represents backscatter energy from stationary and very slowly
swaying (velocity < .5 wavelength/sec, peak sway < .25 wavelength) or
quasi-stationary scatterers and is well represented by an impulse. Since the
phase summation from these scatterers generally result in different magnitudes
at the receiving antenna terminals for different carrier frequencies, this
"DC" component scintillates with carrier frequency. Therefore, the impulse
coefficients and the DC-to-AC ratios given in Table A3 represent average
values. Even though the "AC" component of the backscatter energy from moving
scatterers may include AM as well as FM terms, the density functions used in
this model assumes that the spectral spread will be inversely proportional to
the carrier wavelength.

The clutter from a single resolution cell fluctuates as a function of
time and frequency. The fluctuation density functions which define the
scintillation of both "DC" and "AC" components of a single cell as a function
of frequency and different cells with the same mean is exponential. The
temporal fluctuation of the backscatter of a single cell when observed with a
single carrier frequency is, due only to the moving scatterer component and is
defined to follow the Ricean density function given in equation A4 using the
DC-to-AC ratios given in table A3.

$$(A4) \quad p(\overline{\sigma_o}(t)/\overline{\sigma_{oK}}=\overline{\sigma_{oe}}) = \frac{(m^2+1)\exp\left[-\frac{\sigma_o}{\sigma_{oe}}(m^2+1)\right]\exp\left[-m^2\right]I_o\left[2m\sqrt{m^2+1}\sqrt{\frac{\sigma_o}{\sigma_{oe}}}\right]}{\sigma_{oe}}$$

where m^2 is the DC-to-AC power ratio, $\overline{\sigma_{oe}}$ = a value that can be taken by $\overline{\sigma_{oK}}$ and
$I_o[x]$ is the modified Bessel Function of the first kind of zero order.
Unambiguous samples from different resolution cells represent uncorrelated
samples of the uniformly distributed phase distribution. The spatial
correlation coefficient of the clutter mean reflectivity is given in Table A8.

3.2 SEA CLUTTER - The mean reflectivity $\overline{\sigma_{oк}}$ of the distributed sea clutter is defined to have a spatial amplitude density function $p_к(\overline{\sigma_{oк}})$ that is gamma (See Figure A4) with the expected values of $\overline{\sigma_{oк}}$ as given in Table A4. Note that this gamma distribution is a function of the parameter k which, in turn, is a function of the size of the radar resolution cell. Conditional densities $p(\sigma_o(t)/\overline{\sigma_{oк}}=\sigma_{oe})$, $p(\sigma_o(R_i)/\overline{\sigma_{oк}}=\sigma_{oe})$, and $p(\sigma_o(w)/\overline{\sigma_{oк}}=\sigma_{oe})$ are exponential. Therefore, $p(\sigma_o(t))$ and $p(\sigma_o(R_i))$, which can be obtained thru equations (A1a) and (A1b), are K-distributions (See Figure A5) [1],[2],[3],[4],[9].

The power spectral density function of sea clutter is defined to be Gaussian with the equivalent velocity characteristics given below:

* Sea State V

    Mean Doppler shift: 5.0 $\cos\Theta_w$ (knots) Horizontal polarization
    3.0 $\cos\Theta_w$ (knots) Vertical polarization

    Standard Deviation: 3.0 (knots)

* Sea State II

    Mean Doppler shift: 3.5 $\cos\Theta_w$ (knots) Horizontal polarization
    1.5 $\cos\Theta_w$ (knots) Vertical polarization

    Standard Deviation: 1.0 (knots)

where Θ_w = angle between the wind direction and the radar beam. The mean reflectivity values correspond to waves that move in space in the direction of the surface winds at 18 knots. Unambiguous samples from different resolution cells represent uncorrelated samples of the uniformly distributed phase distribution. The spatial correlation coefficient of the mean reflectivity is given in Table A8. For calculations of multipath, see Table A11.

The sea also contains ships and buoys which are modeled as discretes. Within 20 nm of the radar site, the average density of the discretes is 1 per 10 square nautical miles (42 discretes total within 20 nm). Beyond 20 nm, the density is 1 per 250 square miles. The distribution of median RCS is the same as that given in Table A1 for the mean value of terrain discretes. However, multipath and other propagation factors are not included in RCS values for the ships and buoys. For each site and propagation condition, the power density on the discrete depends on the multipath and refraction conditions over the water. The shape of each discrete is assumed to be roughly rectangular with a height (ht) given by

$$ht = antilog((RCS-25)/40)$$

where ht = height of ship/buoy in meters and RCS = effective radar cross section of discrete in water. The fluctuation about the median value of a discrete is defined to be log-normal with a standard deviation of 1.15 (5 dB between 84% and 50% points). The autocorrelation function is exponential with a decorrelation time of 1 second. The speeds of the ships/buoys are uniformly distributed between plus and minus 25 knots; the headings are random with respect to the site.

3.3 WEATHER CLUTTER - Precipitation clutter is defined to exist when a storm system moves into the radar coverage. For the purposes of this evaluation, a simple model of a storm system is used where the area of the system is roughly square and has dimensions of 200 nm by 200 nm. Precipitation within this storm system exists in two forms: distributed and cellular. The spatial characteristics of cellular and distributed precipitation are defined in Table A5 and Table A6 for two generalized climatic environments, tropical and middle latitude. The tropical environment model depicts high intensity- smaller diameter rain cells that are often found in the summer weather systems experienced in Hawaii and Guam, the Gulf states of CONUS and at some sites in Arkansas and Oklahoma. The middle latitude model, which depicts moderate intensity-larger diameter rain cells, presents a weather system typical of the rest of the sites in CONUS. These models were derived from information obtained from Beals, et al [5].

The cellular precipitation is modeled by cylindrically shaped cells with core rainfall rates and diameters given in Table A5. The rainfall rate falls off horizontally outside this core at 20.8 mm/hr per nautical mile for the middle latitude region and at 32.4 mm/hr per nautical mile for the tropical latitude regions. The middle latitude cellular precipitation consists of 170 cells with a typical diameter of 3.1 nm at the 2.5 mm/hr rainrate points for weaker cells, increasing to over 5 nm for the strongest cells. The tropical precipitation is modeled by 233 smaller cells. Most of the cells contain higher rainrate cores which extend over less area. The cells travel in groups with 5-10 cells per group. The cross sectional area of each group is irregularly shaped and is 100 square nautical miles in size. These groups are uniformly distributed within the storm system. For the tropical environment, the distributed precipitation exists only within the cell groups between the cells. For the middle latitude environment, the distributed precipitation exists between the cells within the group and between the cell groups throughout the storm system.

The number of rain cells within 100 nm given in Table A5 defines the total number in the storm system and, therefore, the peak number within 100 nm as the system passes through. However, detection of the cells as they approach or leave the radar coverage volume is not limited to 100 nm and is determined by the radar horizon and height of precipitation.

Table A6 defines the relationships between rainfall rate, frequency, backscatter amplitude and attenuation. The propagation loss for any given path shall also include the atmospheric loss as given in NRL Report 6930. Table A6 also defines the amplitude and spectral statistics of the precipitation backscatter. Note that the weather backscatter is treated as a nonstationary process with the mean reflectivity $\overline{n}_{vk}$ varying in space about expected values calculated from the mean rainrate of the cell. Since $p_K(\overline{n}_{vk})$ is gamma (See Figure A4) and the conditional densities $p(n_v(t)/\overline{n}_{vk} = n_{ve})$, $p(n_v(R_i)/\overline{n}_{vk} = n_{ve})$, and $p(n_v(w)/\overline{n}_{vk} = n_{ve})$ are exponential, $p(n_v(t))$ and $p(n_v(R_i))$ are a K-distributions calculated thru equations (A1a) and (A1b).

Table A7 defines the average horizontal wind speed as a function of height and presents the formulas for calculating the spectral spread of the rain backscatter. Average fall rates of precipitation are given in Table A5. While real convective systems have vertical velocities that can be positive (updrafts) or negative (downdrafts), only negative vertical velocities are given in the model. The wind in the clear or in distributed rain is assumed

to be unidirectional with moderate shear with altitude. Within the groups containing cellular rain, a circular wind pattern causes the speed and direction of the wind-blown rain to vary in different regions and altitudes within the cell due to terrain effects, convective activity, and the turbulence and shear along warm and cold fronts. Therefore, large regions of the cell will display large radial wind shears regardless of the angle between the nominal wind direction within the 200 nm radar coverage and the radar beam. In this model, this azimuth-independent wind shear is assumed to apply to the whole cell.

The mean velocity of an elemental volume is obtained by the vector summation of the horizontal and vertical velocities. The radial velocity component from an elemental volume of rain has a spread around the mean velocity due turbulence and the distribution of fall velocities. This spread is assumed to be Gaussian with the standard deviations given in Table A7. When a larger volume containing a spread of mean velocities is observed, the resultant spectral shape can be obtained by convolving the distribution of mean velocities with the Gaussian spread caused by turbulence and the distribution of fall velocities. Calculation of the spread of mean velocities due to windshear as well as beam spread components require the use of the proposed antenna pattern or a Gaussian approximation with the same two-way beamwidth. To the extent that the elevation (or azimuth) pattern, including sidelobes or Gaussian tails, observes a constant rainrate, the spectral shape of the wind shear (or beam broadening) component is the shape of the two-way antenna pattern. When a gaussian pattern is assumed and the rain fills the pattern out to insignificant levels, then the simplified equations for spectral spread given in Table A7 and reference [10] apply. However, when the rain partially fills the pattern or different rainrates are observed in different regions of the pattern, then the spectral shapes are obtained by weighting the contribution of each scattering volume with the antenna gain in the direction of that volume. As shown in the examples given in Figure A9, this can lead to non-Gaussian shapes even if a Gaussian antenna pattern is used.

The spatial correlation coefficient of the mean volume reflectivity is given in Table A8. Unambiguous samples from different resolution cells represent uncorrelated samples of the uniformly distributed phase distribution.

3.4 ANGEL CLUTTER - This model describes the number and characteristics of small moving scatterers such as birds and insects within the detection volume. The angel characteristics and distributions are summarized in Table A9. The distribution of mean angel RCS is lognormal and is plotted in Figure A6. This model assumes that all angels are small relative to a resolution cells.

200,000 angels are defined to be randomly distributed within a 250 nm radius of the site and are confined to within 16,000 feet of sea level. This corresponds to an average density of .4 angels per cubic mile or 1 angel over each square mile of surface area. Table A9 defines a non-uniform distribution of angels in altitude. At each site overlooking the sea and lowland terrain, the refraction conditions will determine the effective angels density above the radar horizon. Figure A7 provides the number of angels that are both above the radar horizon and within radius R for each site assuming standard refraction conditions. Numbers for superrefractive and anomalous propagation

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conditions are calculable in a similar manner. For Wooded Hills and Mountain terrain, the number of angels above the radar horizon given in Figure A7 is defined to exist for all conditions. Multipath effects have not been included and must be accounted for in determining the detection statistics for angel clutter.

3.5 GROUND VEHICLES - The model describing the local vehicular traffic is summarized in Table A10. Ground vehicles follow roads that exist at known locations around the site and are randomly oriented with respect to the site. This traffic is visible to the radar in the same regions that the lowland distributed clutter is visible. Traffic is also visible in the highland clutter patches within 50 nm of the site. 500 vehicles are visible along the 50 nm of highway within line of sight of the high   sited radar during any given scan. The longest continuously visible stretch of highway is 5 nm and the shortest stretch is .5 nm. Due to screening, 50 vehicles are visible along the 5 nm of visible highway near the low site. The longest stretch of continuously visible highway is .5 nm. and the shortest is .1 nm. Ground speeds of each vehicle are assumed to be constant while traveling on visible stretches of the highways.

3.6 ANOMALOUS PROPAGATION - Superrefractive and ducting conditions exist at the Lowland site a large percentage of the time. The major impact of superrefractive propagation over the terrain is to extend the range of clutter.   This effect is modeled by assuming that the equivalent earth radius is 5 times the true earth radius rather than 4/3. The superrefractive layer exists from ground or sea level to 400 feet MSL; normal refraction resumes above 400 feet MSL.

Ducting is modeled by assuming that energy is trapped and guided around the curvature of the earth. Energy transmitted with elevation angles of plus or minus .1 degree from the 350 ft radar site and less than .3 degree from surface scatter is trapped by a duct with a height of 400 feet MSL. Energy transmitted at angles above .1 degree and .3 degree, respectively, propagate according to standard refraction.

Sea state II conditions exists during anomalous propagation conditions. The mean backscatter is a function of grazing angle via superrefractive propagation out to 10.4 nm where the grazing angle is .3 degree. Beyond this range, the effective grazing angle at the sea surface will slowly vary in range (correlation lengths of several miles) from a maximum of .3 degree to 0 degrees. The power density at the sea surfaces in the duct are calculated assuming free space propagation losses.

At the far coastline, the duct gives way to superrefractive propagation over the terrain. For the purpose of calculating the terrain clutter amplitude, the effective grazing angle as a function of radial distance from the coastline can be calculated by

$$(A5) \qquad \phi_g = \sin^{-1}\left(\frac{.0255}{R+7} - \frac{R+7}{34400}\right)$$

where R is the radial range inland from the coastline in nautical miles and ϕ_g is the grazing angle.

The spectral spread of the sea return is the same as under normal propagation conditions. The spectral spread of the ducted terrain backscatter is modified by the multiple reflections from the moving surfaces of the duct. The resultant spectral distribution is the convolution of the lowland spectrum defined by Table A3 and a Gaussian spectrum with a zero mean frequency and a standard deviation corresponding to 2.5 knots.

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TABLE A1-SPATIAL AMPLITUDE DISTRIBUTION FUNCTION OF TERRAIN BACKSCATTER

**The mean reflectivity values $\overline{\sigma_{oi}}$ for elemental areas within the distributed clutter patches follow a Weibull distribution

$$P(\overline{\sigma_{oi}} \leq \sigma_{oe}) = 1-\exp[\,(-\ln 2)(\sigma_{oe}/\sigma_M)^c\,]$$

Parameter	(σ_M)	(c) $F(\phi_g)$
Lowlands,tundra	$.1 \sin^2(\phi_g)$	$F(\phi_g)$
Wooded Hills	.000631 (-32 dB)	.35
Mountains	.002 (-27 dB)	.40

where ϕ_g = grazing angle in radians; $0 < \phi_g < .22$ radians

$$F(\phi_g) = \begin{cases} 4.22/10\log[\,(.078/\phi_g^{1.4})+1.10\,] & \text{for } \phi_g > .0052 \text{ radians} \\ .2 & \text{for } \phi_g \leq .0052 \text{ radians} \end{cases}$$

**Stationary discretes or point clutter

RCS (dBsm)	60	50	40	30	20	10	0
% of discretes	1	2	5	10	20	27	35

TABLE A2 - SPATIAL POSITION DISTRIBUTION FUNCTION OF TERRAIN BACKSCATTER FROM HILLS AND MOUNTAINS

$F_r(x)$ = Percentage of clutter patch area within radius x of site given truncation range r

$$F_r(x) = \frac{1 - \exp(-x/b)}{1 - \exp(-r/b)} \qquad b = \text{mean range of distribution}$$

WOODED HILLS   b = 45.9 nm

x (nm)	20	40	60	80	100	120	140	160	180
$F_{180}(x)$	.361	.593	.744	.842	.905	.946	.972	.989	1.0
$F_{100}(x)$	.398	.655	.822	.93	1.0	---	---	---	---

PATCHES WITHIN RADIUS x

	20	40	60	80	100	120	140	160	180
5nm x 5deg.	47.8	78.6	98.6	111.6	120	136.2	146.7	153.5	158
10nm x 10deg	12.7	21	26.3	29.8	32	---	---	---	---
20nm x 20deg	2.8	4.6	5.7	6.5	7.0	---	---	---	---

MOUNTAINS   b = 37.8 nm

x (nm)	20	40	60	80	100	120	140	160	180
$F_{180}(x)$	.414	.659	.802	.887	.937	.966	.984	.994	1.0
$F_{100}(x)$	.442	.703	.856	.947	1.0	—	—	—	—

PATCHES WITHIN RADIUS x

	20	40	60	80	100	120	140	160	180
2.7nm x 5deg	77.8	123.7	150.7	166.7	176	192.6	202.3	208.1	211.5
5.4nm x10deg	19.4	30.9	37.7	41.7	44	—	—	—	—
10.8nm x20deg	4.9	7.7	9.4	10.4	11	—	—	—	—

TABLE A3 - SPECTRAL DENSITY FUNCTION OF TERRAIN

** Lowlands

   ** For 20 knot winds, DC to AC Ratio = .85

$$S(f) = .46\, \delta(f) + .3284\, \lambda/[1 + (|f|\, \lambda/.68)^3]$$

$$R(\tau) = \int_{-\infty}^{\infty} S(f)\, e^{2\pi f \tau}\, df$$

   ** For 10 knot winds, DC to AC Ratio = 5

$$S(f) = .833\, \delta(f) + .2211\, \lambda/[1 + (f\lambda/.34)^4]$$

$$R(\tau) = .833 + .167\, \exp(-1.511\tau/\lambda)[\cos(1.511\tau/\lambda) + \sin(1.511\tau/\lambda)]$$

** Wooded Hills, DC to AC Ratio = 9

$$S(f) = .9\, \delta(f) + .3881\lambda/[1 + (f\lambda/.116)^4]$$

$$R(\tau) = .9 + .1\, \exp(-.5154\tau/\lambda)[\cos(.5154\tau/\lambda) + \sin(.5154\tau/\lambda)]$$

**Mountains and Discretes, DC-to-AC power ratio = 27

$$S(v) = .964\, \delta(f) + .3523\, \lambda/[1 + (f\lambda/.046)^4]$$

$$R(\tau) = .964 + .036\, \exp(-.2044\tau/\lambda)[\cos(.2044\tau/\lambda) + \sin(.2044\tau/\lambda)]$$

v = equivalent radial velocity in meters/second = f λ/2
f = frequency in Hz.
λ = wavelength in meters
τ = time delay in seconds

TABLE A4 – SPATIAL AMPLITUDE DISTRIBUTION FUNCTION OF SEA CLUTTER REFLECTIVITY COEFFICIENT

** The mean reflectivity $\overline{\sigma_{ok}}$ varies around the expected value η_i and follows a gamma probability density function

$$P_k(\overline{\sigma_{ok}}) = [\, k^k \overline{\sigma_{ok}}^{k-1} \exp(-k\overline{\sigma_{ok}}/\eta_i\,) / (\Gamma(k)\, \eta_i^k\,)]$$

where, for grazing angles $i < 5$ degrees,

$k = (ct_p/2D)\,|\cos\theta_w| + (R\theta/D)\,|\sin\theta_w|$

θ = two-way azimuthal beamwidth, radians

$\Gamma()$ = gamma function

t_p = pulse width in nsec.

η_i = expected value of $\overline{\sigma_{ok}}$ at grazing angle ϕ_{gi} as given below

R = range, feet

θ_w = angle between wind direction and propagation of radar energy

c = .984 ft/nsec $\approx$ 1 ft/nsec

D = correlation length (See Table A8) = D_λ

For horizontal polarization,

$k \cong (t/200)\,|\cos\theta_w| + (R\theta/100)\,|\sin\theta_w|$ SEA STATE V (D_λ = 100 ft)

$k \cong (t/80)\,|\cos\theta_w| + (R\theta/40)\,|\sin\theta_w|$ SEA STATE II (D_λ = 40 ft)

For vertical polarization,

$k \cong (t/6)\,|\cos\theta_w| + (R\theta/3)\,|\sin\theta_w|$ BOTH SEA STATES (D_λ = 3 ft)

The normalized gamma distribution function defined as

$$PROB(y \le y) = \int_{-\infty}^{y} P_k(x)\, dx$$

is plotted in Figure A4 for k equal to 1, 2, 4, 16, and infinity and where $y = \overline{\sigma_{ok}}/\eta_i$

SEA STATE II

$\eta_i = -25 + 20\log(\sin(\phi_{gi}))$ (dB) for $\phi_{gi} < 5$ degrees   (Vertical)

$\eta_i = -52 + 20\log(\sin(12\,\phi_{gi}))$ (dB) for $\phi_{gi} < 5$ degrees   (Horizontal)

SEA STATE V

$\eta_i = -32 + 17\log(\sin(12\,\phi_{gi}))$ (dB) for $\phi_{gi} < 5$ degrees   (Vertical)

$\eta_i = -40 + 15\log(\sin(12\,\phi_{gi}))$ (dB) for $\phi_{gi} < 5$ degrees   (Horizontal)

TABLE A5 - WEATHER SPATIAL CHARACTERIZATION

	MIDDLE LATITUDES		TROPICAL LATITUDES	
Cellular Precipitation				
* Core height	0-15,000 feet		0-20,000 feet	
* Number of cells within 100 nm radius	170		233	
* Size and Rainfall Rate				
Mean Rainfall Rate (mm/hr)	Number of cells	Diameter (nm)	Number of cells	Diameter (nm)
2.5	47	3.1	58	2.2
6.3	46	2.7	53	2.0
12.5	45	2.1	45	1.6
25	18	1.6	35	1.1
50	14	0.8	25	0.8
100	--		17	0.6

	MIDDLE LATITUDES	TROPICAL LATITUDES
*Edge falloff		
* Horizontal	20.8 mm/hr/nm	32.4 mm/hr/nm
* Vertical	1.5 mm/hr/kft	1.5 mm/hr/kft (1 - 50 mm/hr) 2.5 mm/hr/kft (100 mm/hr)
* Fall Rate	15 knots	15 knots
Distributed Precipation		
*Uniform Light Rain		
*Height	0 to 9000 feet	0 to 13000
*Mean Rainfall Rate	1 mm/hr	1 mm/hr
*Areal Extent	Throughout storm system bwt cells	Within clusters between cells
*Fall Rate	10 knots	10 knots
*Bright Band		
*Equivalent Rainrate	10 mm/hr	10 mm/hr
*Vertical Extent	9Kft to 10Kft	13Kft to 14.5Kft
*Fall Rate	2 knots	2 knots

TABLE A6 - WEATHER BACKSCATTER AND ATTENUATION RELATIONSHIPS

** The mean volume reflectivity $\overline{n_V}$ varies about the expected value η_m and follows a gamma density function

$$P_k(\overline{n_v}) = [\ k^k\ \overline{n_v}^{k-1}\ \exp(-k\ \overline{n_v}/\eta_m\ )/\ \{\Gamma(k)(\eta_m^k\ )\ \}\ ]$$

Relationship Between
Average Rainrate and $\eta_{m(L)} = (6.12 \times 10^{-14})\{r^{1.6}/\lambda^4\}$ m^2/m^3
$\eta_{m(L)}$ for Linear
Polarization

Amplitude Scintillation
Distribution Function   exponential

Attenuation Factor $a = .00013\ (f)^{2.36}\ r$
(dB/nm, one way)

* Average % of 185.2 km radial occupied by rainrate for use in calculation of average attenuation (1 degree elevation angle)

Average Rainrate(mm/hr)	1.8	3.8	8.9	17.8	35.6	70
*Middle Latitude	3.3	1.7	1.4	0.8	0.02	0
*Tropical Latitude	3.5	1.1	0.9	0.55	0.15	0.11

Polarization   -15 dB for rain
Characterization $\eta_{m(c)}/\eta_{m(L)} =$ {-10 dB for bright band
                                                   -15 dB for water above
                                                       cylinder core

where   r = mean rainfall rate, millimeters/hour
            λ = wavelength, meters
                 f = frequncy, gigahertz
        $\Gamma(\ )$ = gamma function
                 k = $(1+R\theta/2U_r)*(1+ct/4U_r)$
        $\eta_{m(L)}$ = expected value of rain reflectivity using
                     linear polarization
        $\eta_{m(c)}$ = expected value of rain reflectivity using
                     circular polarization

TABLE A7 - WIND VELOCITY AND WEATHER SPECTRUM

HORIZONTAL WIND VELOCITY

* ENVIRONMENTAL WINDS
  These winds are unidirectional and exist in Clear weather or within
  the distributed rain

    * Mean Velocity = 10 knots, gusting to 20 knots $\quad$ h < .2 kft

    * Mean Velocity = 10 + .5h (knots) $\qquad$ .2 kft < h < 20 kft

    * Mean Velocity = 20 + 1.7(h÷20) (knots) $\quad$ 20 kft < h

* CELLULAR RAIN
The mean velocity component of cellular scatterers in the direction of
environmental winds is 20 knots. Within the cell below 20 kft, circulating
winds exist that present a wind shear due to changes in wind velocity and
direction as a function of height. For the purposes of this procurement, a
simple shear model that assumes a linear increase of circulating wind speed
with altitude is used. The mean radial velocity V as a function of altitude
is given as

$$*V_r = 20 \cos \theta_w \cos \phi_e + 15 \sin \phi_e + j \, 2.35 \, (h \div 10) \cos \phi_e \text{ (knots)}.$$

Above 20 kft, the winds are the unidirectional and the mean radial velocity
is given as

$$*V_r = 44 \cos \theta_w \cos \phi_e + 2.35 \, (h \div 20) \cos \theta_w \cos \phi_e \text{ (knots)}.$$

SPECTRAL SPREAD:
*When a Gaussian antenna pattern is filled with uniform rain,

$$S_v^2 = [\, (TURB)^2 + (FALL)^2 + (WIND \, SHEAR)^2 + (BEAM \, SPREAD)^2]$$

where
$\qquad$ TURB = standard deviation (s.d.) of turbulence = 1.4 (knots)
$\qquad$ FALL = s.d. of fall velocities = 2 $|\sin \phi_e|$ (knots)

WIND
SHEAR $\begin{cases} = \text{s.d. of shear} \\ = 1.27 \, R \, \phi \, \cos \phi_e \, |\cos \theta_w| \text{ (knots) (distributed rain)} \\ = 6.0 \, R \, \phi \, \cos \phi_e \text{ (knots) (cellular rain)} < 20 \text{ kft} \\ = 6.0 \, R \, \phi \, \cos \phi_e \, |\cos \theta_w| \text{ (knots) (cellular rain)} > 20 \text{ kft} \end{cases}$

BEAM SPREAD = .42 V θ $|\sin \theta_w|$ (knots)
$\qquad$ R = range in nm
$\qquad$ ϕ = two-way elevation beamwidth containing rain (radians)
$\qquad$ θ = two-way azimuthal beamwidth containing rain (radians)
$\qquad$ ϕ_e = elevation angle (radians)
$\qquad$ V = mean wind velocity at center of beam (knots)
$\qquad$ θ_w = angle between wind direction and radar beam (radians)
$\qquad$ S_v = std. deviation of wind velocity, (knots)
$\qquad$ h = altitude, (kilofeet MSL)
$\qquad$ j = +1 or -1, random from rain cell to rain cell
When antenna pattern is not filled, the spectral shape depends on the location
and intensity of the rain within the filled portion of the beam as illustrated
in Figure A9.

TABLE A8 - SPATIAL CORRELATION COEFFICIENT OF CLUTTER MEAN REFLECTIVITY

$$d(\Delta \ell) = \begin{cases} 1-(|\Delta \ell|/D) & \text{for} \quad |\Delta \ell| < D \\ 0 & \text{for} \quad |\Delta \ell| > D \end{cases}$$

*Lowlands	D_r = 3000 ft
*Mountains	D_r = 1000 ft for R ≤ 50 nm
or Hills	= 1000 (R/50) ft, R>50 nm (note 1)
*Sea	= 100 feet for SS V_{HH}
	D_u = 40 feet for SS II_{HH} (up/down wind)
	= 3 feet for all SS_{VV}
	D_c = R θ or $ct_p/2$ in the cross wind direction
*Weather	
cellular	D_r = 500 ft (range/cross range dimension)
	D_α = vertical height of core
distributed	D_r = 2.0 nm (range/cross range dimension)
	D_α = vertical height of 1 mm/hr precipitation

where

$$d(\Delta \ell) = E\left\{ (u_i^*(\ell) - \eta_\mu^*)(u_i^*(\ell + \Delta \ell) - \eta_\mu^*) \right\} /(\sigma_\mu^*)^2$$

η_μ^* = expected value of u_i^*

$(\sigma_\mu^*)^2$ = variance of u_i^*

u_i^* = 10 log u_i

$u_i^*(\ell)$ = sample of u_i^* at location ℓ

c = 300 meters/usec = 984 ft/usec

R = range, nautical miles

θ = Az. 2-way beamwidth in radians

t_p = waveform pulsewidth in microseconds

note 1: Due to shadowing, the spacing between the visible weibull scatterers is assumed to increase proportional to range.

TABLE A9 - ANGEL CLUTTER MODEL

NUMBER OF ANGELS < 250 NM RADIUS   200,000

AVERAGE DENSITY   .4 angel per cubic mile; 1 angel over each sq. mile

DISTRIBUTION OF ANGEL RCS (See Figure A6)

*Density function	Log Normal
*Median	-20 dBsm
*84 Percentile	-10 dBsm
*Fluctuation statistics	Swerling I

GROUND SPEED AND HEADING

* Bounds of ground speed, time interval between heading changes, and angle of heading change is a function of height.
* Sampling distribution is uniform between bounds in each case.

SPATIAL DENSITY

Altitude Interval (kft)	% of angels	Ground Speed (knots)	Heading Changes (degrees)	Time Between Heading Changes (minutes)
0 - 1	50	0-30	+180/-180	0 - 1
1 - 2	25	10-40	+180/-180	1 - 5
2 - 4	20	30-60	+90/-90	5 - 10
4 - 8	4.5	30-60	+30/-30	5 - 15
8 - 16	0.5	30-60	+30/-30	5 - 15

TABLE A10 - GROUND VEHICLES

VEHICLE RCS	10 square meters Swerling 1

GROUND SPEED
   *Distribution
  - *Mean
   *Standard deviation
	Gaussian
	50 knots
	10 knots

NUMBER OF VISIBLE VEHICLES PER SCAN	500 (Highland site) 50 (Lowland site)

TABLE A11 - MULTIPATH PARAMETERS [6],[7],[8]

$$F = |f(\phi_1) + r p_o Df(\phi_2)\exp(-j\alpha)|$$

where

$f(\phi_1)$ = antenna gain at direct path ray angle ϕ_1

$f(\phi_2)$ = antenna gain at reflected path ray angle ϕ_2

r = $\exp(-8(\pi S_H \sin \phi_3/\lambda)^2)$

p_o = magnitude of reflection coefficient of smooth surface
(See Figure A8a for vertical polarization and
Figure A8c for horizontal polarization.)

D = .6

α = $\psi + (2\pi \ell/\lambda)$

ψ = phase angle of reflection coefficient
= 180 degrees for horizontal polarization $\phi_3 <$ 10 degrees)
(See Figure A8b for vertical polarization)

ℓ = path length difference of direct and reflected rays

λ = wavelength, meters

ϕ_3 = grazing angle

S_H = $\begin{cases} .6 \text{ meters for Sea State V} \\ .1 \text{ meters for Sea State II} \end{cases}$

TABLE A12 - LIST OF SYMBOLS

a = attenuation factor for rain

c = speed of propagation = 300,000,000 meters/second

$d(\Delta\ell)$ = spatial autocorrelation function

f = Doppler frequency in Hertz

h = altitude

k = number of uncorrelated samples of u_1 within resolution cell

ℓ = a measure of distance in range, cross-range, or altitude

m^2 = DC-to-AC power ratio

$n_v(t_1)$ = instantaneous volume reflectivity of a cell at time t_1. (Boldface type indicates random variable)

$\overline{n_{vk}}(t_1,R_i')$ = mean volume reflectivity for cell i of size k at time t_1. (Boldface type indicates random variable)

$p(u)$ = probability density function of u

$p_k(u_k)$ = spatial amplitude density function of u_k where the resolution cell contains k uncorrelated samples of u_1

$p(z/a)$ = conditional density function of the random variable z given condition a.

q = normalized instantaneous reflectivity z/η_μ

r = rainrate in mm/hr

s_v = standard deviation of wind velocity

s_H = standard deviation of wind height

t = time in seconds

t_ρ = pulse width

$\overline{u_k}(t_1,R_i')$ = the mean value of reflectivity for cell i of size k at time t_1 for a generalized distributed clutter source. (Boldface type indicates random variable.) Analogous to the areal reflectivity term $\overline{\sigma_{ok}}$ and the volume reflectivity term $\overline{n_{vk}}$

v = radial velocity

w = carrier frequency

$z(t_1)$ = the instantaneous value of reflectivity for a cell at time t1 for a generalized distributed clutter source. (Boldface type indicates random variable.) Analogous to the areal reflectivity term $\overline{\sigma_o}$ and the volume reflectivity term n_v.

A = the area of a resolution cell

B = the instantaneous bandwidth of a waveform

D = the correlation length, the distance between uncorrelated samples of u_1

$P(u < b)$ = the probability of random variable u being equal to or less than value b

R = range in nautical miles

R_i' = location of cell i in vector notation

RCS = the radar cross section in square meters

V = mean wind velocity in knots

V_r = mean radial wind velocity in knots

$\delta(\ )$ = delta function

η_μ = expected value of random variable $u = \bar{u}$

θ = antenna -3 dB two-way beamwidth in azimuth

θ_α = azimuth angle α

θ_w = the azimuth angle between the wind direction and the radar beam

λ = wavelength, meters

$\sigma_o(t_1)$ = instantaneous areal reflectivity of a cell at time t_1. (Boldface type indicates random variable.)

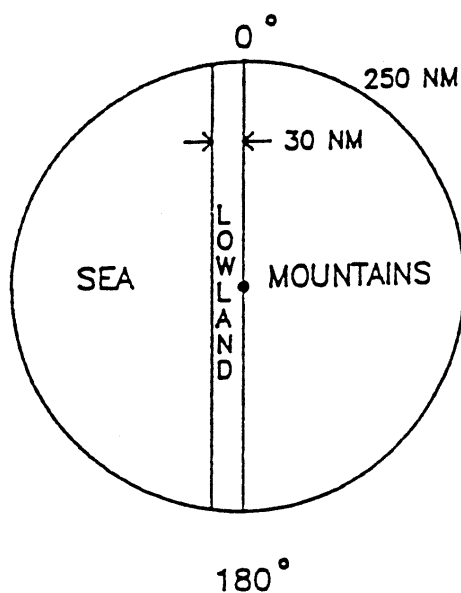$\overline{\sigma}_{o\kappa}(t_i, R_i)$ = average areal reflectivity of cell i of size k at time t_1. (Boldface type indicates random variable.)

σ_{oe} = a value that can be taken by $\overline{\sigma}_{o\kappa}$

σ_u = standard deviation of random variable u_1

γ = time delay

ϕ = antenna -3 dB two-way beamwidth in elevation

ϕ_e = elevation angle ϵ

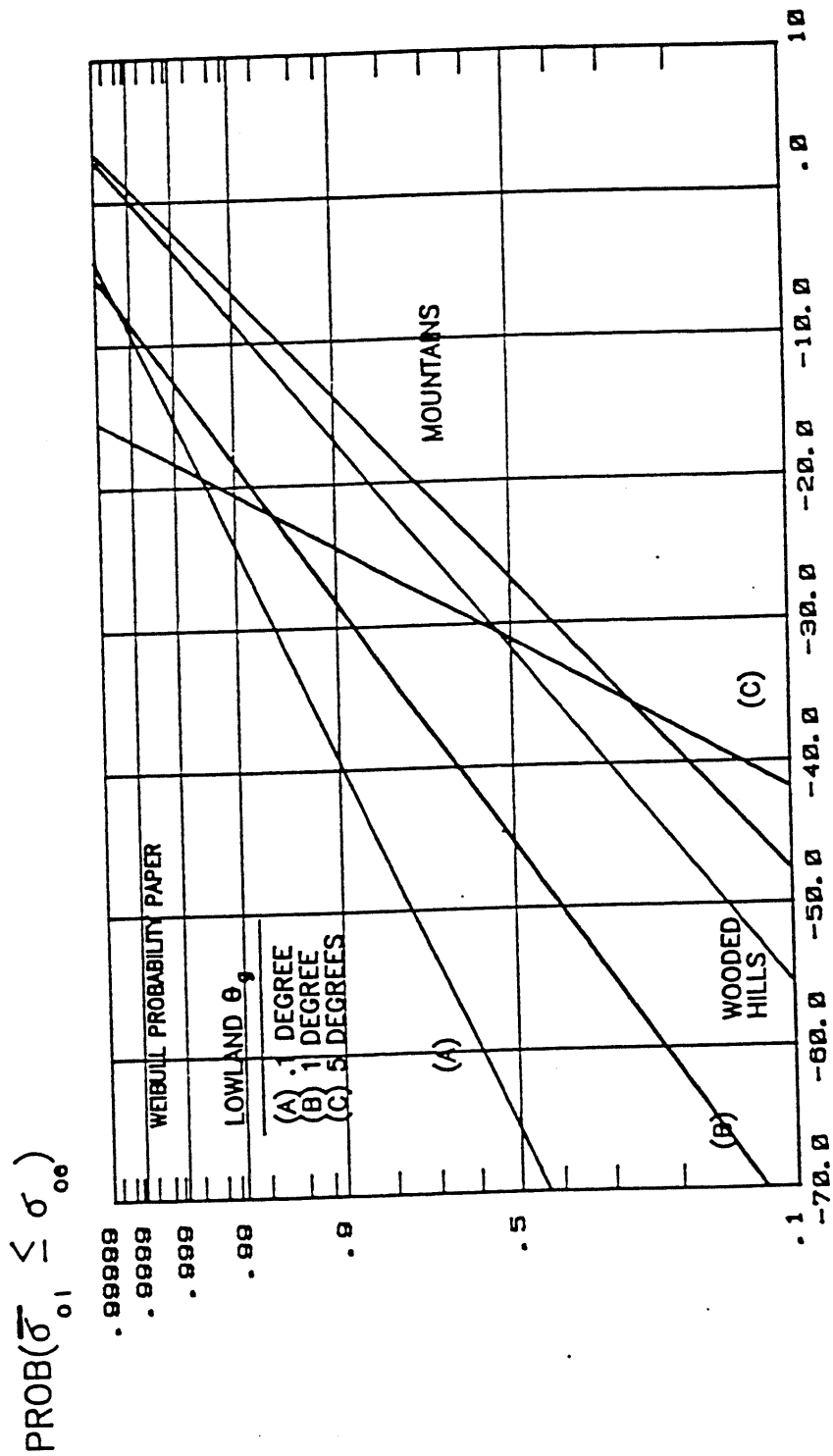ϕ_g = grazing angle

$\Gamma( )$ = gamma function
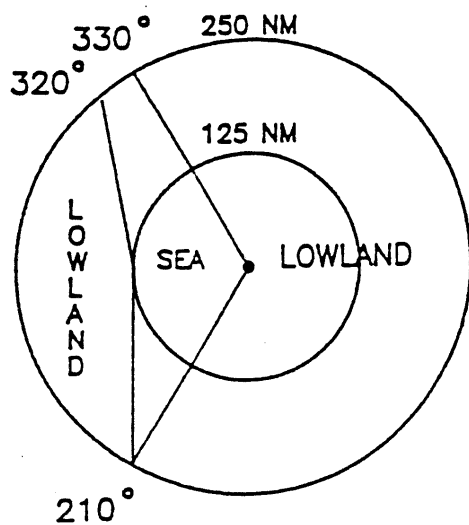
(a) LOW SITE
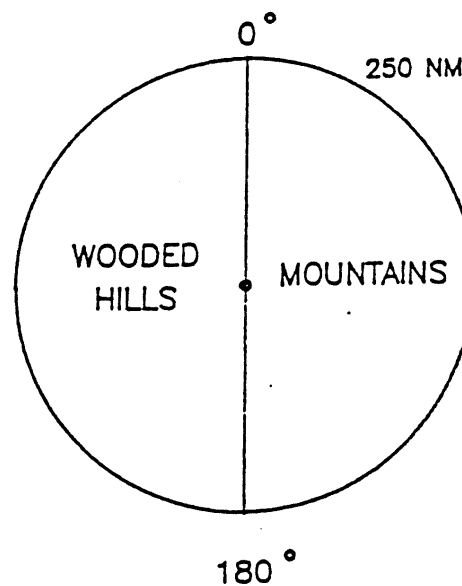
(b) HIGH SITE #1

(c) HIGH SITE #2

NOTE:

All boundaries between clutter types are irregular.

FIGURE A1 SITE ENVIRONMENTS

FIGURE A2 SPATIAL DISTRIBUTION OF MEAN REFLECTIVITY FOR TERRAIN

RELATIVE AC
POWER DENSITY
(SECONDS)

FREQUENCY (HZ)
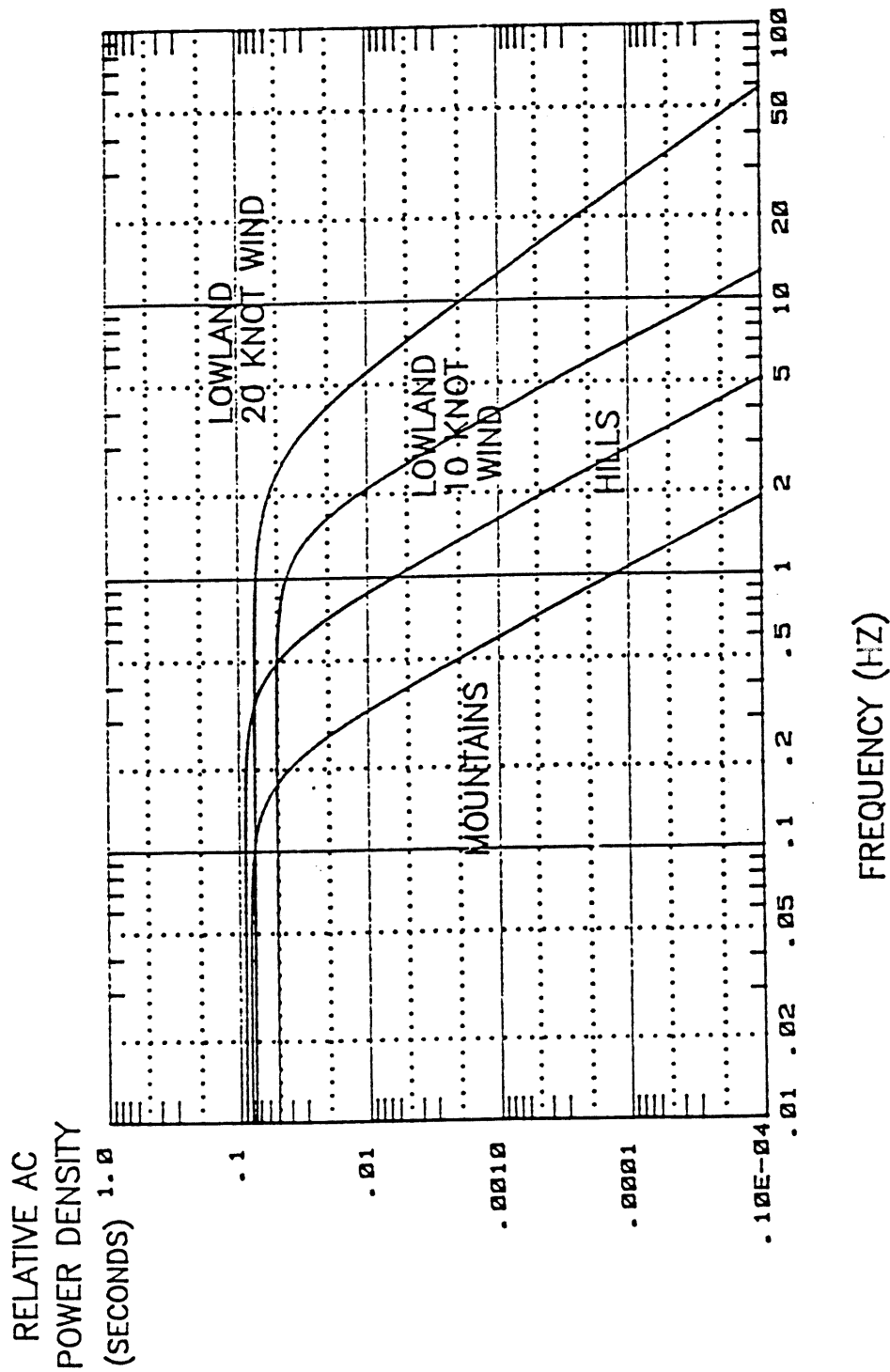
FIGURE A3a SPECTRAL DENSITY OF LAND CLUTTER AC POWER

WITH CARRIER WAVELENGTH λ = .23 METERS
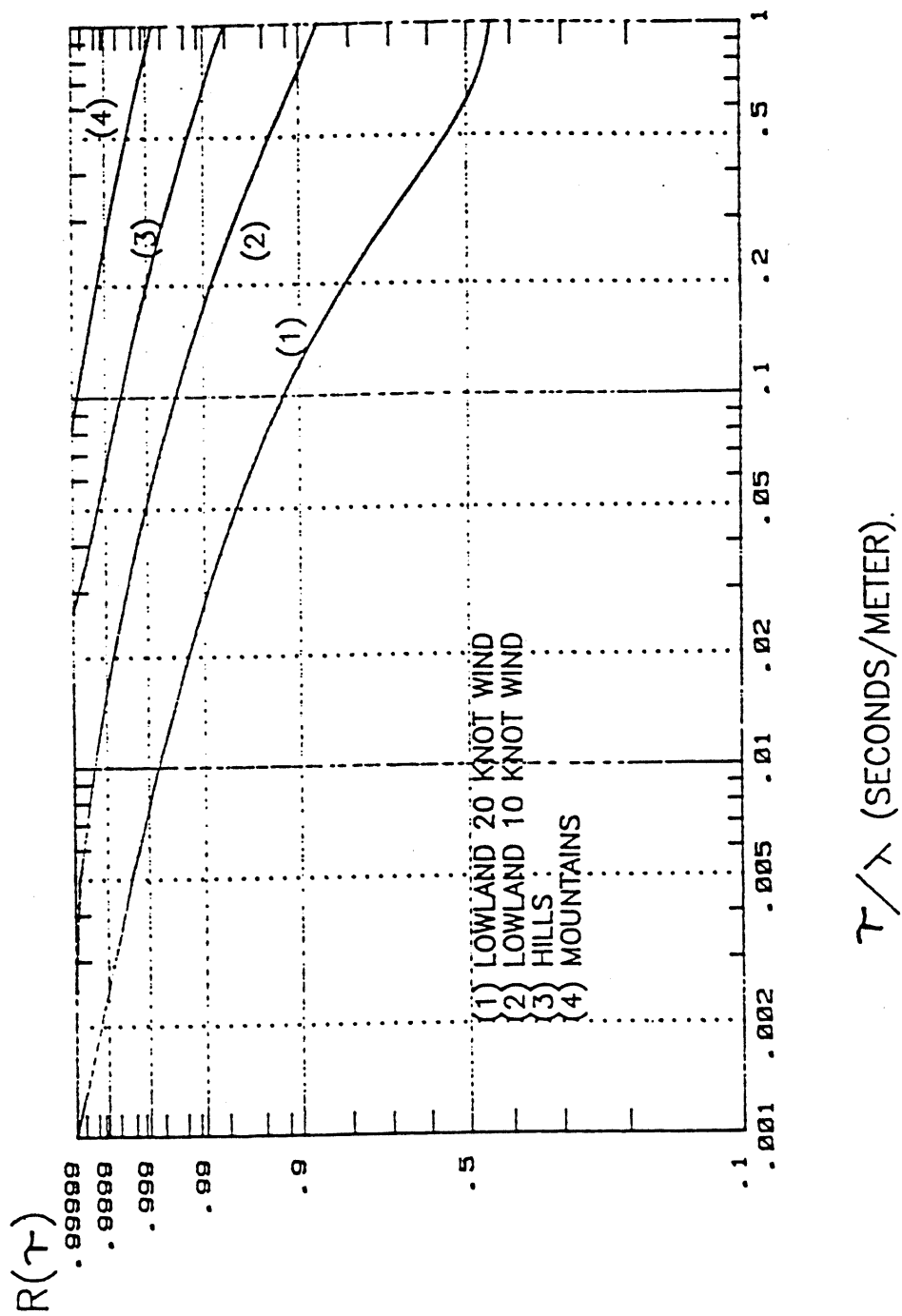
FIGURE A3b AUTOCORRELATION OF LAND CLUTTER
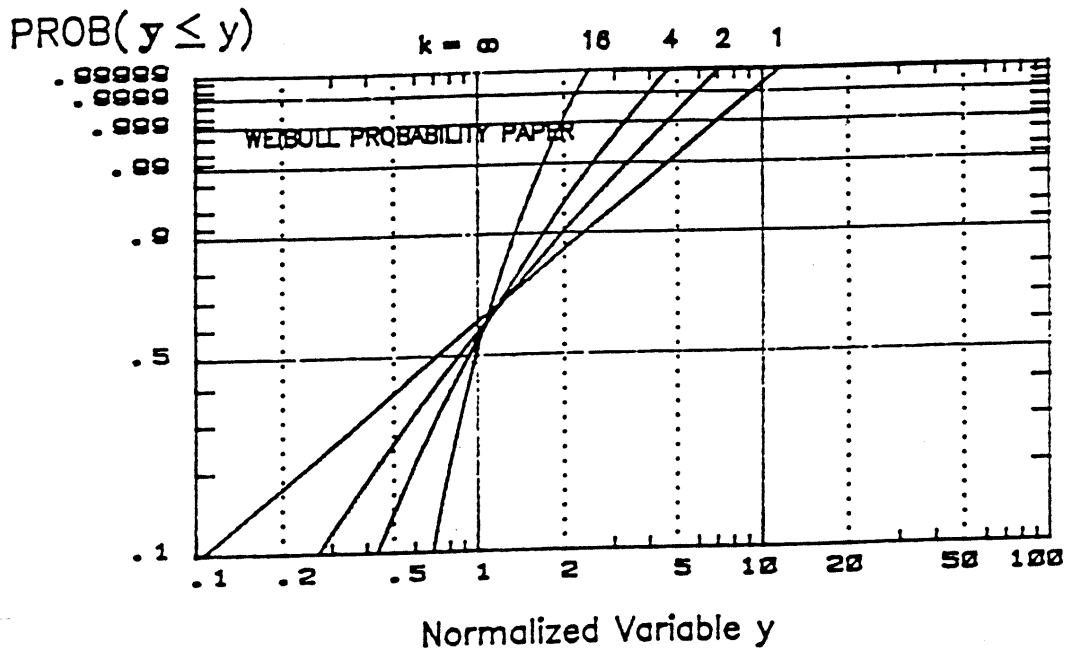
PROB($y \leq y$)

$$p(y) = k^k y^{k-1} \exp(-ky)/\Gamma(k)$$

$$PROB(y \leq y) = \int_{-\infty}^{y} p(z) \, dz = 1 - (\exp(-ky))(\sum_{i=0}^{i=k-1} (ky)^i /i!)$$
$$\text{for } k=\text{integer}>0$$

y and u represent values that can be taken by the respective
random variables y and u.

$y = u/\bar{u}$

$y = u/\bar{u}$

$\Gamma( )$ = gamma function

$k = \bar{u}^2/\sigma^2$
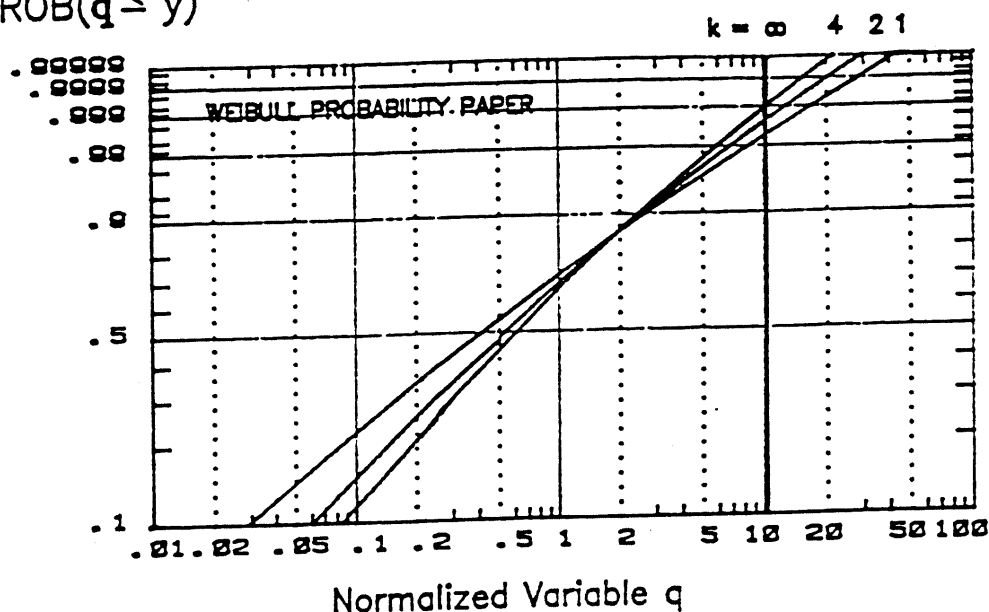
$\bar{u} = \int_{0}^{\infty} u \, p(u) \, du$

σ = variance of u

$p(u) = k^k u^{k-1} \exp(-ku/\bar{u})/\Gamma(k) \bar{u}^k$

FIGURE A4   NORMALIZED GAMMA DISTRIBUTION

PROB($q \leq y$)

Normalized Variable q

$$p(y) = \frac{2 \, k^{\left(\frac{k+1}{2}\right)} \, y^{\left(\frac{k-1}{2}\right)}}{\Gamma(k)} \, K_{1-k}\left(2\sqrt{ky}\right)$$

$$PROB(q \leq q) = \int_{-\infty}^{y} p(z) \, dz \underset{\substack{\text{for}\\ k\text{-integer}}}{=} 1 - \frac{2 \, (ky)^{\frac{k}{2}}}{\Gamma(k)} \, K_k\left(2\sqrt{ky}\right)$$

$K_v(\ ) =$ modified Bessel function of the second kind
of order v

q and z represent values that can be taken by the respective
random variables q and z

$q = z / \bar{u}$ $\bar{u} = \int_0^\infty u \, p(u) \, du$

$q = z / \bar{u}$ $\sigma =$ variance of u

$\Gamma(\ ) =$ gamma function $p(z) = \int_0^\infty p(z/u) \, p(u) \, du$

$k = \bar{u}^2/\sigma^2$ $p(z/u) = \exp(-z/u)/u$

                              $p(u) = k^k u^{k-1}\exp(-ku/\bar{u})/\Gamma(k) \, \bar{u}^k$

FIGURE A5   NORMALIZED K–DISTRIBUTION

PROB (x > X)

RADAR CROSS SECTION X (DBSM)
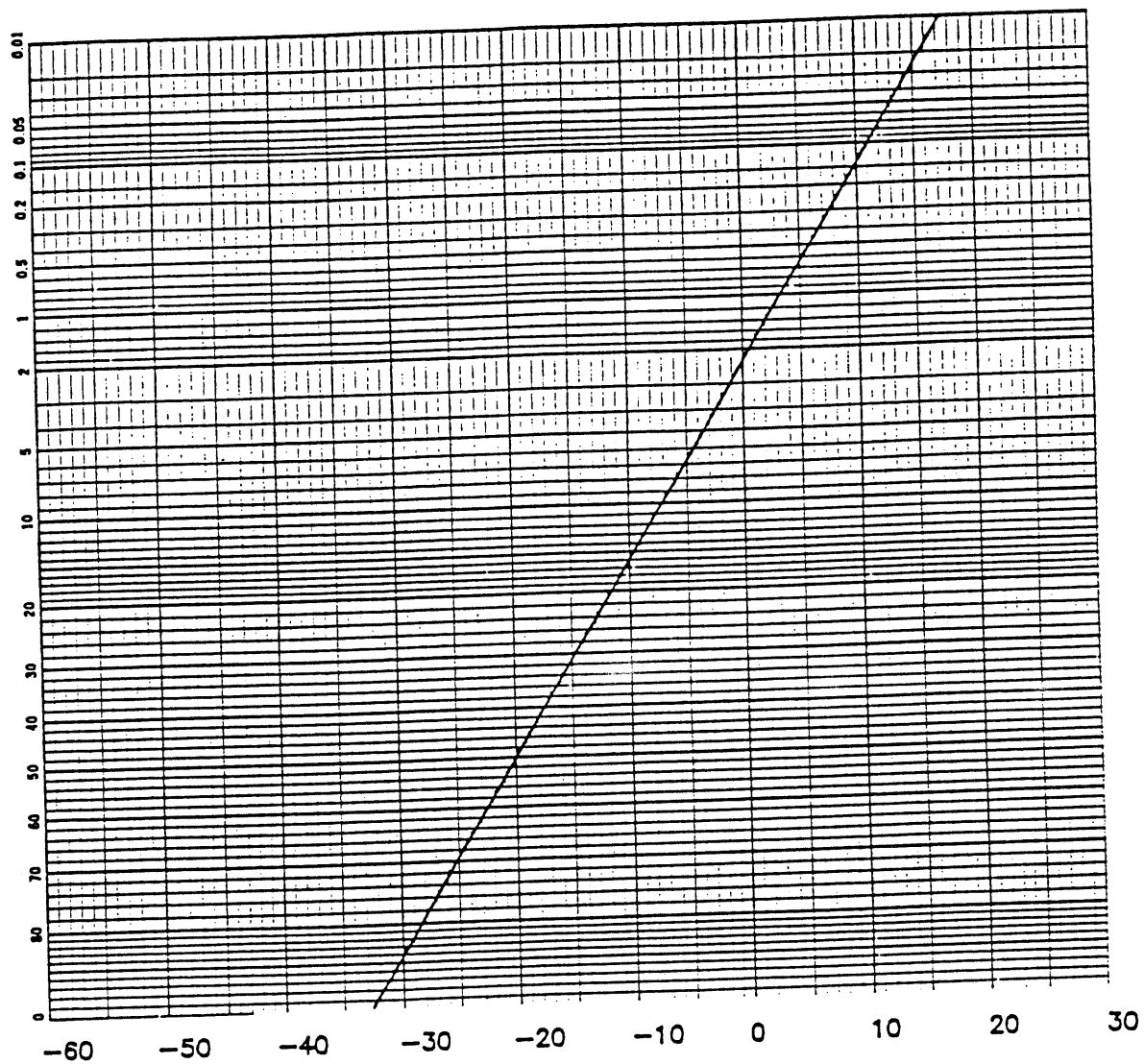
p.d.f. $= f(X) = \dfrac{\exp(-(\ln(X/m))^2/2s^2)}{X s (2\pi)^{.5}}$ median $= m = .01$ sm

PROB $(x > X) = 1 - \displaystyle\int_0^X f(z)\, dz$ std. deviation $= s = 2.303$

FIGURE A6   DISTRIBUTION OF ANGEL RCS

LOW SITE OVERLOOKING THE SEA

LOW SITE OVERLOOKING LOWLAND

HIGH SITE OVERLOOKING SEA AND LOWLAND

RANGE R (NM)

RANGE R (NM)

RANGE R (NM)

RANGE R (NM)

Number
of
Angels
Within
Range
R Per
Degree
In
Azimuth

Number
of
Angels
Within
Range
R
Per
Degree
In
Azimuth

Number
of
Angels
Within
Range
R
Per
Azimuth
Degree

KEY

A   Total Number of Angels

B   Surface to 1000 Ft

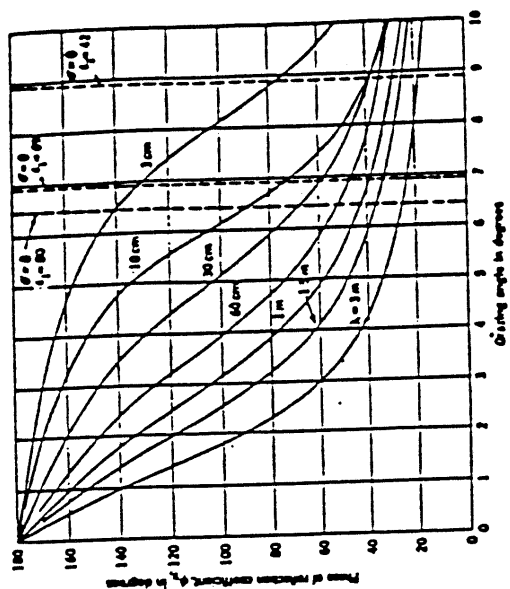C   1000 Ft to 2000 Ft

D   Above 2000 Ft
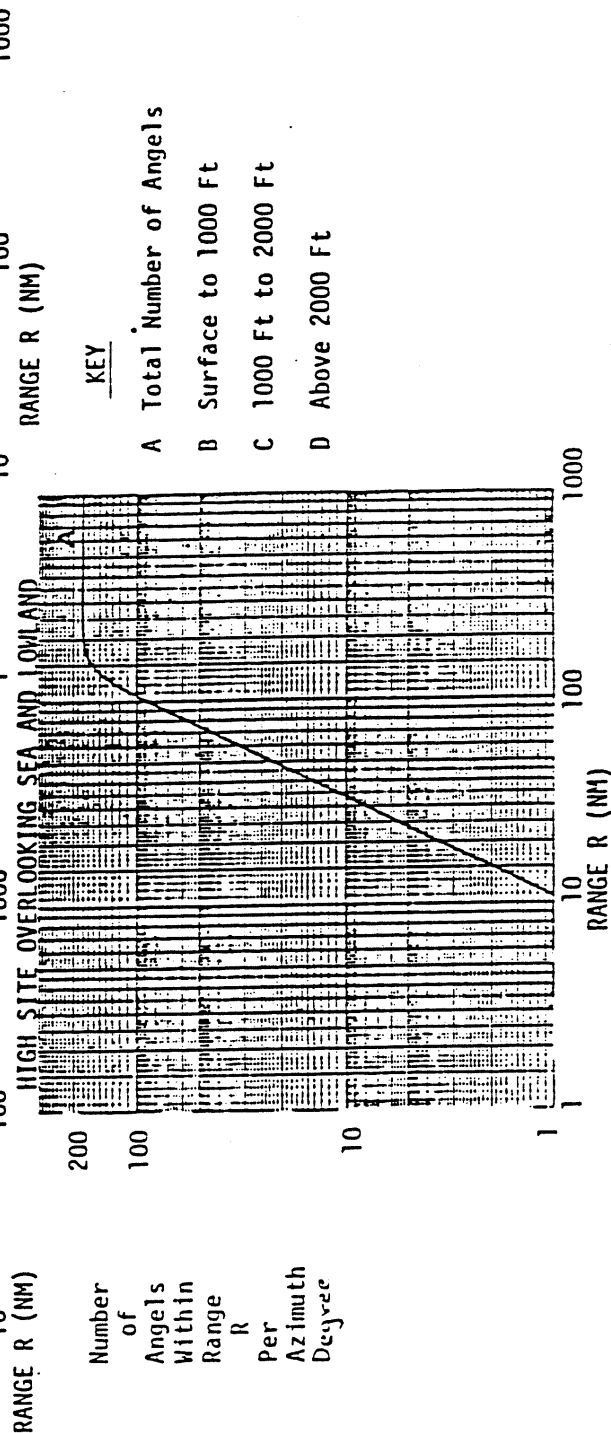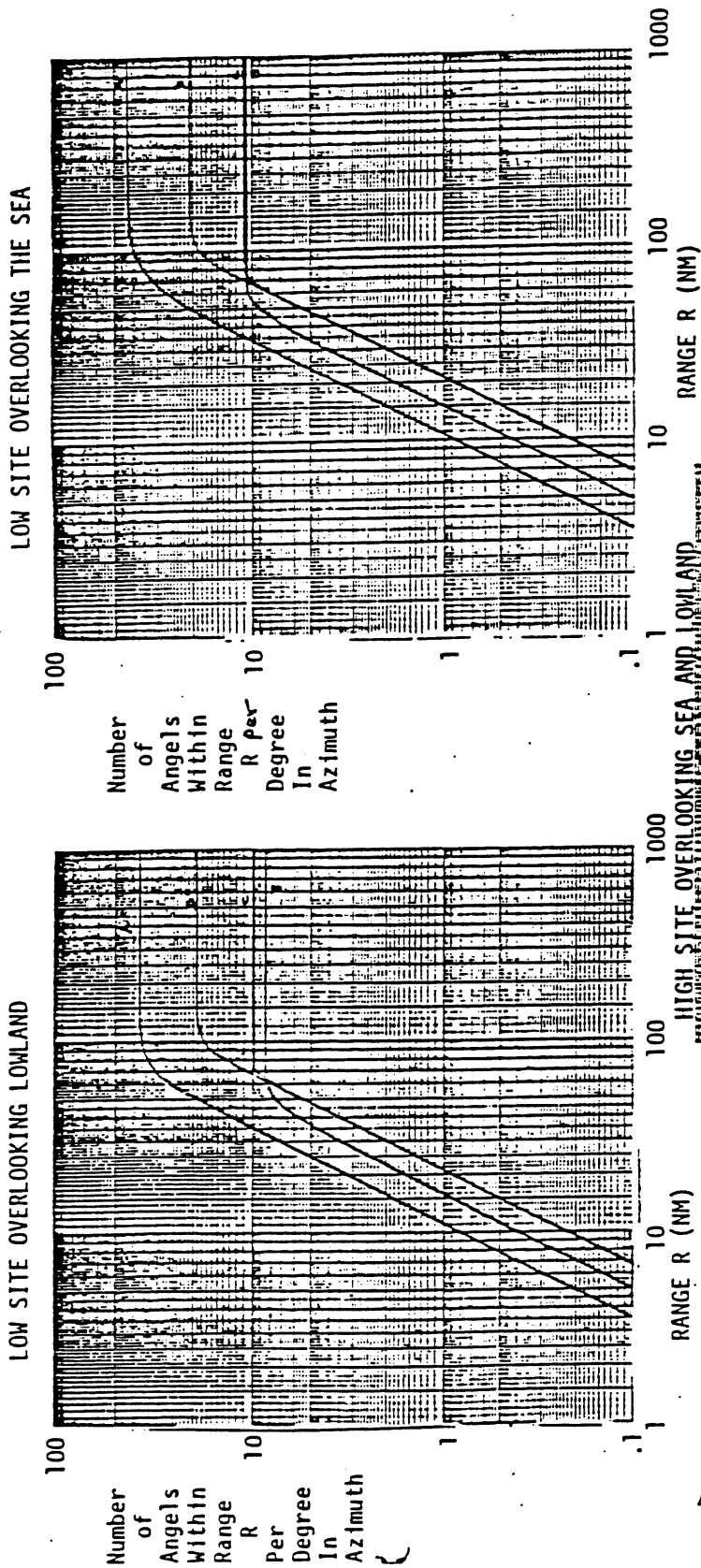
Figure A8b - Phase of the reflection coefficient θ as a function of grazing angle for a smooth sea and vertical polarization. [6]
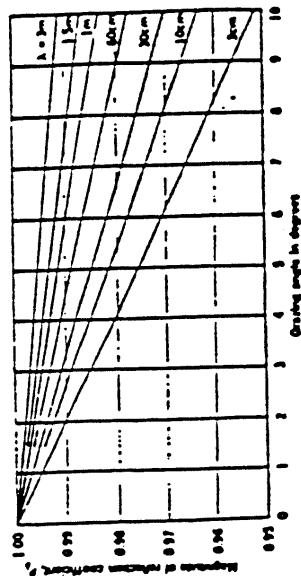

Figure A8c - Magnitude of the reflection coefficient ρ as a function of grazing angle for a smooth sea and horizontal polarization. [6]
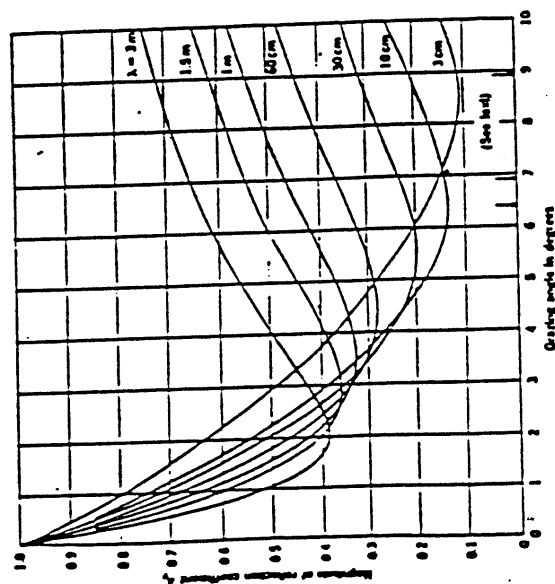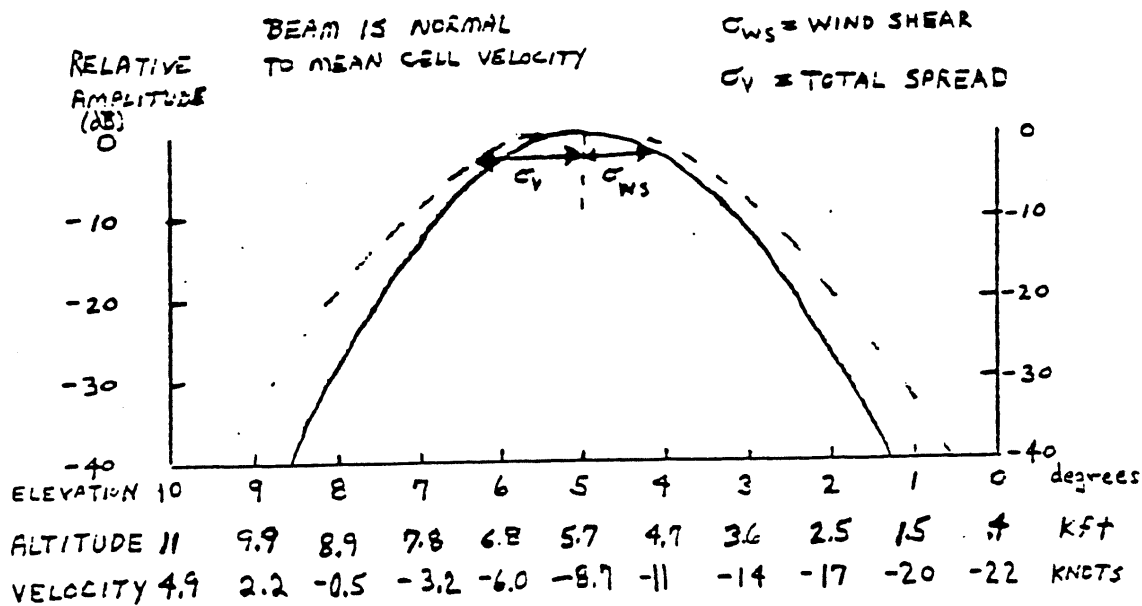

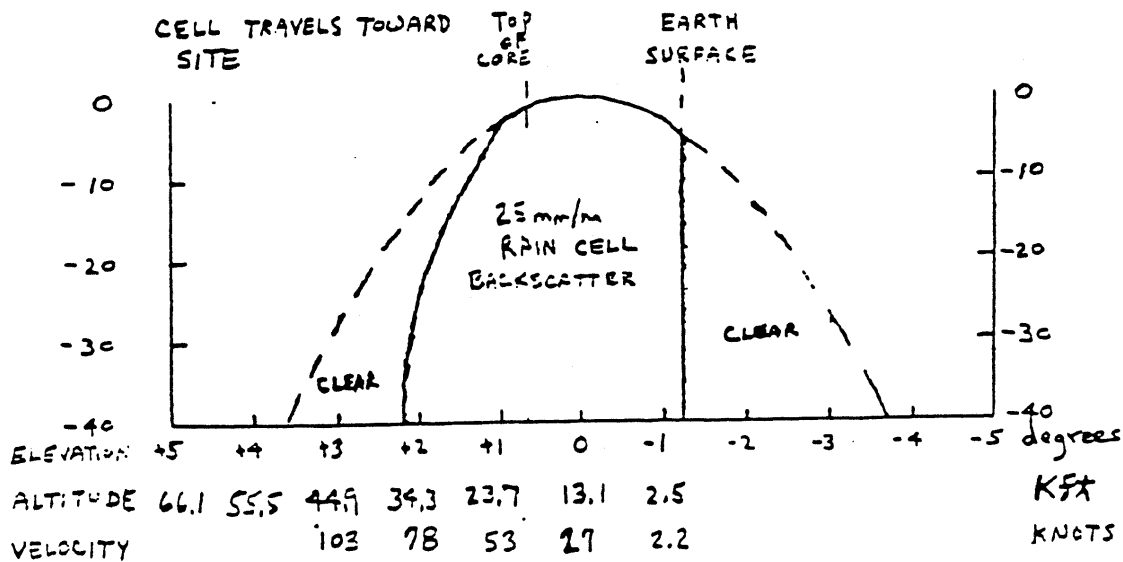Figure A8a - Magnitude of the reflection coefficient ρ as a function of grazing angle for a smooth sea and vertical polarization. [6]

RELATIVE
AMPLITUDE
(dB)

BEAM IS NORMAL
TO MEAN CELL VELOCITY

σ_{WS} = WIND SHEAR

σ_V = TOTAL SPREAD

ELEVATION	10	9	8	7	6	5	4	3	2	1	0	degrees
ALTITUDE	11	9.9	8.9	7.8	6.8	5.7	4.7	3.6	2.5	1.5	.4	kft
VELOCITY	4.9	2.2	-0.5	-3.2	-6.0	-8.7	-11	-14	-17	-20	-22	KNOTS

a. FILLED GAUSSIAN BEAM (RANGE=10NM, BW_{-3dB}=2°)
(LOW SITE) (j=+1)

CELL TRAVELS TOWARD
SITE

TOP OF CORE

EARTH SURFACE

25 mm/m
RAIN CELL
BACKSCATTER

CLEAR

CLEAR

ELEVATION	+5	+4	+3	+2	+1	0	-1	-2	-3	-4	-5 degrees
ALTITUDE	66.1	55.5	44.9	34.3	23.7	13.1	2.5				Kft
VELOCITY			103	78	53	27	2.2				KNOTS

b. PARTIALLY FILLED GAUSSIAN BEAM (RANGE =100NM,
-3dB BW = 2°, 6500 ft site, j =+1)
FIGURE A9 : SPECTRA OF RAIN

APPENDIX B

MODE 4 AND STROBE PROCESSING

Appendix B is the classified portion of the ARSR-4 Specification (FAA-E-2763).
It provides information pertaining to Mode 4 and strobe processing and is
composed of two parts. Part I pertains to Mode 4 (3.5.20) and Part II
pertains to strobe processing.

This appendix is available via written request to the program office.

> Federal Aviation Administration
> ASU-320
> Attn: ARSR-4 Contracting Officer
> 800 Independence Avenue, SW
> Washington, DC 20591

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APPENDIX C

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APPENDIX D

SUBCLUTTER VISIBILITY MEASUREMENTS WITH THE TEST TARGET GENERATOR

1.0 Definition.- The subclutter visibility is defined as the ratio of clutter signal to target signal when the target signal is exactly superimposed on the clutter signal and a probability of detection of 0.8 as achieved at each point over the specified radial velocities. If a non-fluctuating target is used in lieu of a Swerling I target, the subclutter visibility measurement must be reduced by 5.5 dB.

2.0 Test Methods.- The subclutter visibility measurements shall be made with the radar connected to the antenna, the transmitter on, and the antenna scanning normally. The method to be used is as follows:

(a)   Determine the range and azimuth of a large isolated fixed echo.

(b) . Adjust the STC or other front-end attenuator until that echo is on the verge of limiting the A/D converters.

(c)   Superimpose the search test target (STTG) signal over the clutter signal and select an appropriate velocity.

(d)   Reduce the amplitude of the test target generator signal until the blip-scan ratio at the target extraction output is 0.8.

(e)   Increase the amplitude of the test target generator signal by adjusting the precision attenuator until the test target generator signal and the clutter signal are the same amplitude as observed on an expanded A-scope display of the IF amplifier output.

(f)   Repeat the above test for other velocities.

The measured subclutter visibility is the difference in dB between the attenuator readings taken in steps (d) and (e) above.

Some systems can be adjusted so as to produce clutter residue which may lead to optimistic subclutter readings in tests of this kind. Checks shall be made with no target signal to establish that no clutter residue detections occurs for the fixed echo selected. In the event that pulse compression is used, the test shall be modified as necessary to provide a valid subclutter visibility measurement.

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ARSR-4 ANTENNA TEST RANGE REQUIREMENTS AND CONSIDERATIONS

1.0 Antenna Test Range Requirements

This Appendix establishes design guidelines and probe data requirements for the test range(s) that shall be employed in verifying ARSR-4 antenna performance.

The purpose of antenna testing is to determine how the antenna will perform under actual operating circumstances. For this reason, it is important to assess the characteristics of the antenna itself, and not of the antenna in one particular environment. Ideally, the test antenna would be placed in free space with a source antenna at a near infinite separation. This would permit measurement of the characteristics of the antenna in the absence of external interference and in an incident field uniform in both phase and amplitude. However, this is not possible and restrictions must be established on the actual test environment.

The discussion that follows applies to a far field antenna test range. In the event that the contractor proposes the use of a near field range for pattern testing of the ARSR-4 production antennas, the contractor must demonstrate that the near field azimuth patterns and the far field azimuth patterns taken on the first ARSR-4 antenna produce sufficiently comparable results to assure that the subsequent production antenna patterns, tested on the near field range will meet all specified performance requirements. Specifically, all of the antenna specification must be fully met on both the far field and the near field ranges. In addition, the main lobe of the far field patterns and the mainlobe of the near field patterns shall coincide within normal plotting error; the sidelobe amplitudes shall agree within 1.0dB RMS for side lobes of -40dB or higher; the integrated cancellation ratio, for antennas having circular polarization, shall agree within ± 1.0dB; and the antenna gain measurements shall agree within ± 0.25dB. The contractor shall provide evidence to show that the verification also applies to the elevation patterns. Other methods of near field range verification will be considered subject to Government approval.

1.1 Range Length and Probe Data Requirements

The antenna range length shall not be less than $2D^2/\lambda$ for the pattern measurement of the first antenna.

ALUMINUM BEAM
CARRIAGE

HORN ROTATOR

PROBE ANTENNA AND
MIXER

DRIVE MOTOR AND
SYNCHRO PACKAGE

PROBE CARRIAGE

RF CABLE

UPPER AZIMUTH
TURNTABLE

RF CABLE PULLEY

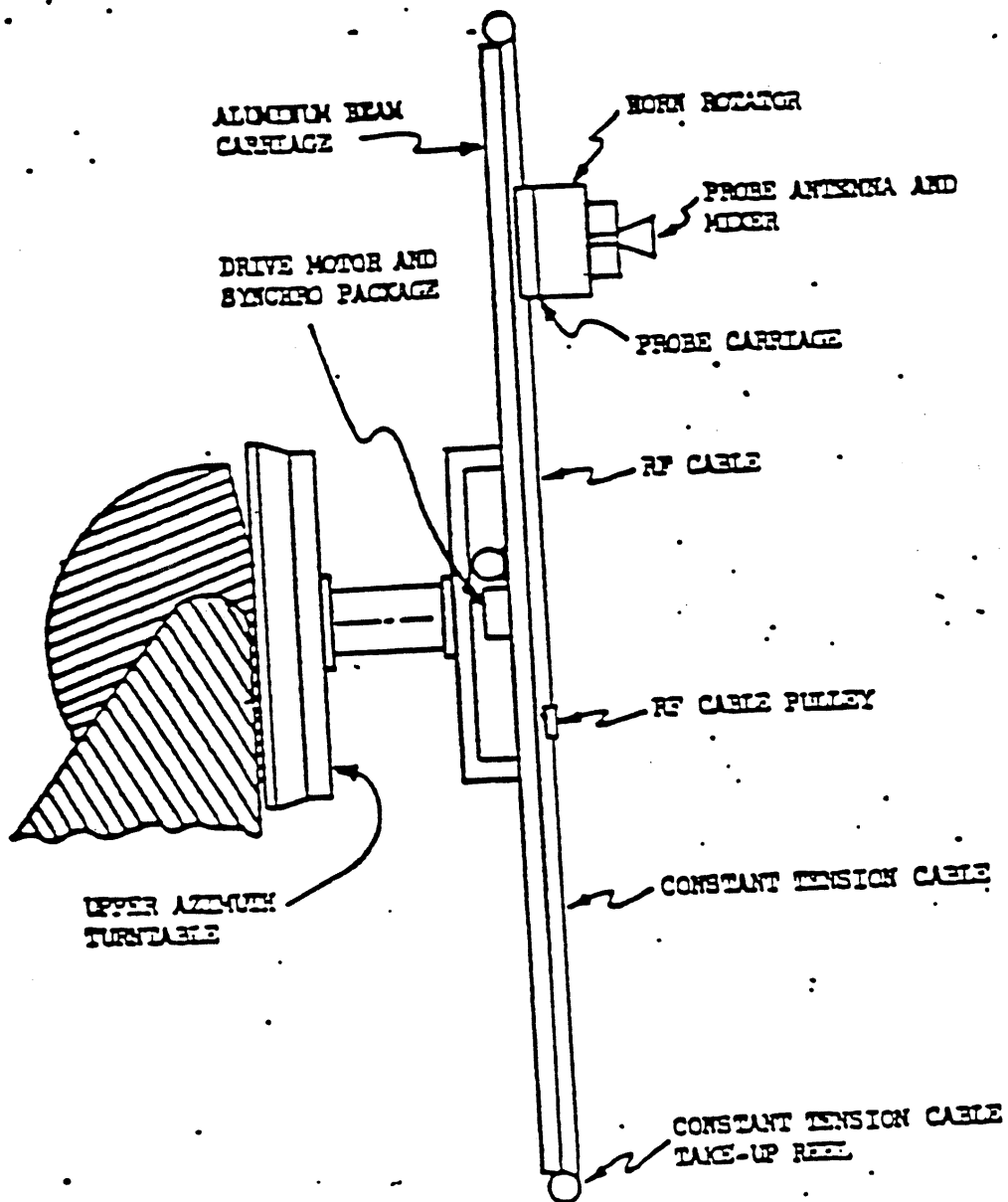CONSTANT TENSION CABLE

CONSTANT TENSION CABLE
TAKE-UP REEL

Figure 1.1   Schematic diagram of field probe mechanism.

The electromagnetic performance of the test range(s) will be verified by recording the probe data described below and reporting these results in the contractor's range validation report. The probe data must meet the requirements established below prior to acceptance of the range(s) as suitable for the testing required by this contract.

A field probe mechanism similar to that shown in Figure 1.1 shall be used for the field measurements required below. The 3-dB elevation and azimuth beamwidths of the probe shall be no less than 30 degrees.

All probe data and related requirements described below are to be demonstrated at 1215 MHz, 1310 MHz, and 1400 MHz.

In the event that different antenna ranges are used for the first antenna and the subsequent production antennas, field probe data shall be furnished for both antenna ranges.

1.2   Probe Measurements Over Test Aperture

The plane normal to the line of sight from the source antenna to the test antenna and passing through the geometrical center of the test antenna aperture when this aperture is also normal to the line of sight is the test aperture plane. The test aperture is the minimum region within the test aperture plane that includes all projections (parallel to the above mentioned line of sight) of the test antenna aperture over all angles of elevation tilt and azimuth rotation employed during antenna testing.

The following probe data and associated performance are required.

(1) With the source antenna oriented to transmit the linearly polarized energy of the ARSR-4 antenna and the field probe antenna oriented to receive the same polarized energy along the line of sight to the source antenna, record the detected signal from the probe antenna as it is moved across the horizontal center line of the test aperture. Repeat this recording with the probe moving along both diagonals across the test aperture (through the center of the test aperture) and along the entire vertical center line of the test aperture.

(a) The amplitude taper, for any recording across the entire test aperture, as determined by measuring the difference between the amplitudes of the maximum and minimum points of the taper shall not exceed 0.25dB for the first antenna (0.50dB for subsequent production antennas).

(b) The amplitude taper shall be centered on the test aperture in the sense that the peak of the taper shall be centered on the test aperture and, for any one recording, the taper levels at the edge of the test apertures shall be the same to within 0.10 dB.

(c) The maximum peak-to-valley variation between maximum and minimum of cyclical variations having the same period shall not exceed 0.2 dB for the first production antenna (0.25dB for subsequent production antennas) when the effects of taper have been accounted for.

(2) With the source antenna oriented to transmit the linearly polarized energy of the ARSR-4 antenna and the field probe oriented to receive orthogonal polarized energy, record the detected signal of the probe antenna as it is moved across the test aperture along the horizontal center line. Reorient the probe antenna to receive the linearly polarized energy of the ARSR-4 and insert 40 dB attenuation in the path of the detected signal. Record the attenuated probe signal as the probe is moved across the test aperture along the horizontal center line. The signal level in the first case shall not exceed the signal level recorded for the later case. Repeat the recordings with the probe moved along both diagonals and the vertical center line across the entire test aperture. For all recordings, the orthogonal polarized signal level shall not exceed the level of the attenuated signal.

(3) If the ARSR-4 antenna is designed to radiate circular polarization, the following antenna range tests shall be performed. With the source oriented to transmit linearly polarized energy, rotate the source antenna in synchronism with the probe antenna and record the received power level. This should be at a number of points over the aperture of the ARSR-4 antenna in the horizontal, vertical and diagonal directions using the field probe mechanism. For one test both antennas must be aligned and maintained to the same polarization. In this case, the variation in signal strength recorded is a direct measure at each point in the field of the ellipticity resulting from the reflections of the same polarization as the direct path signal. The variation between maximum and minimum field strength shall not exceed 0.14 dB. For a second test, the procedure is the same except

both antennas must be aligned and maintained to have their polarization in quardature. In this case, the level of signal compared to the level measured for the first test is a measure of the cross polarization at each point in the field. The maximum value shall be down -42 dB.

(4) The contractor shall submit to the Government as part of the Acceptance Test Procedures required by the SOW, the test procedure proposed to measure the antenna test range reflected energy over 360 degrees of azimuth. The proposed measurement technique shall be adequate to assure that wide angle sidelobes and backlobes of the ARSR-4 antenna can be measured.

2.0 Far Field Antenna Range Considerations

2.1 Introduction

A test environment in which the phase taper across the test antenna is minimal must be provided. If this taper is too severe, the antenna does not integrate the energy over its surface in the same manner as it does at extremely large separations, and the resulting patterns are distorted. Secondly, the amplitude taper across the antenna must be maintained at a minimal amount. The primary effect of moderate amplitude taper in the incident field is to produce errors in the relative levels of the minor lobes of the radiation pattern and to indicate a gain slightly less than the actual value.[1] For most antennas to be tested, an incident field which is constant in amplitude within 0.25 dB over the aperture area should ensure negligible error. Finally, all extraneous energy resulting from reflections from surrounding objects, diffraction effects, etc.. must be kept to, or below, a predetermined level to meet the allowable error requirements for the tests to be made. In addition to the above restrictions which are electromagnetic in nature, test fixtures must have the mechanical stability and positioning accuracy to perform the required tests. These mechanical requirements are very important, but this discussion will be restricted to electromagnetic characteristics, and the above electrical considerations shall be of paramount importance. In the following sections, the elevated range test configuration will be discussed. The design of an elevated range should be directed toward suppressing the unavoidable reflections from the earth's surface by a combination of directive source antennas, large source and receive tower heights, diffraction fences, and judicious positioning of the antenna under test.

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[1] Chastain, J.B., et al, Investigations of Precision Antenna Pattern Recording and Display Techniques, Section 2. AD415-912, April 1963.

2.2 Source antenna Illumination Tapers

2.2.1 Phase Variation of Incident Field

The allowable phase curvature across an antenna under test depends almost entirely on its separation from the source antenna. If the receiving antenna is in the far zone of the transmitting antenna, the phase front of the approaching wave deviates very little from a section of a spherical surface centered on the transmit antenna over the main portion of the main lobe.[2]

This can be seen in Figure 2.1 which is a graph of the calculated phase deviation in degrees over a spherical surface through the main lobe of the beam produced by a circular transmitting aperture.[3] A 30 dB Taylor distribution[4] is assumed and four different distances are assumed from the transmitting antenna to the spherical surface: d^2/λ, $2d^2/\lambda$, $4d^2/\lambda$, and infinity where d is the aperture width of the transmitting antenna.
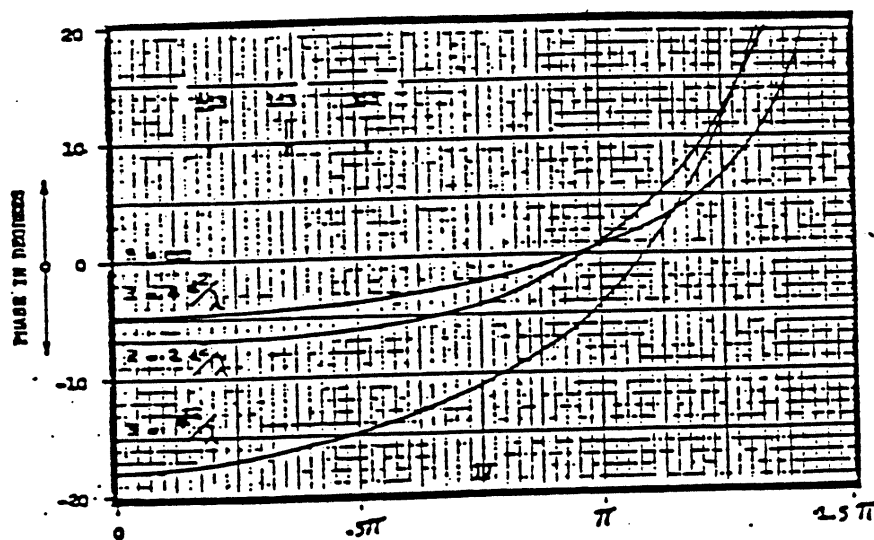

Figure 2.1   Deviation of transmitted phase front from sphere centered on transmitting antenna. R is radius. A 30 dB Taylor aperture distribution is assumed.

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[2]Chastain, J.B., et al, Investigations of Precision Antenna Pattern Recording and Display Techniques, Section 2. AD415-912, April 1963.

[3]Hollis, J.S., et al, Microwave Antenna Measurements, Scientific- Atlanta, Inc.., 1969, p 14-6.

[4]Hansen, R. C., "Tables of Taylor Distributions for Circular Aperture Antennas," IRE Transactions on Antennas and Propagation, Vol.. AP-8, pp. 23-26, January 1960.

The main lobe extends from approximately $U = -1.6\pi$ to $U = 1.6\pi$, where $U = (\pi/\lambda) d \sin\theta$. Even at a range as small as d/λ, the phase front is spherical to within 2 degrees between the 1 decibel points of pattern. This condition is typical of reasonably focused symmetrical antennas. When the transmitting antenna is focused at the test range, the phase front will be essentially that for $R \to \infty$. When the transmitting antenna is significantly defocused, slightly greater phase variation will be experienced. In any event, the deviation of the phase front from spherical between the 1/4 decibel points of the beam will be small.

From Figures 2.1 and 2.2, it can be seen that the phase variation across the area occupied by a test antenna is almost entirely due to the spherical nature of the wave emanating from the transmitter antenna. This deviation can be calculated from the geometry of Figure 2.2.
D is the maximum aperture dimension of the antenna under test and R is the distance from the test antenna to the center of phase of the source antenna.

From the figure,

$$(R + \Delta)^2 = R^2 + (D/2)^2 \qquad (2.1)$$

hence

$$\Delta^2 + 2R\Delta = D^2/4 \qquad (2.2)$$

or

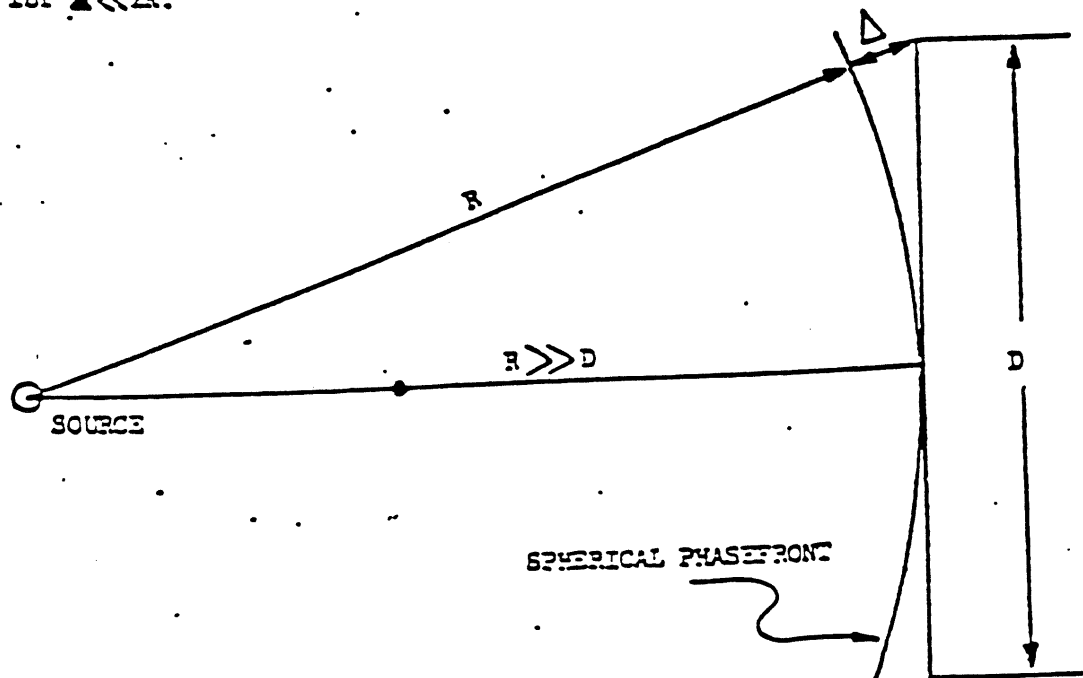$$\Delta = D^2/8R \qquad (2.3)$$

for $\Delta \ll 2R$.

Figure 2.2 Section through incident phasefront at a test separation R >> D.

The resulting phase deviation at the extremes of the test aperture as compared to that at the center is then

$$\delta = \frac{2\pi}{\lambda} \ (D^2/8R) \ \text{radians.} \qquad (2.4)$$

A commonly employed criterion is a phase restriction of 22.5 degrees, ($\delta = \pi/8$), which when substituted into equation (2.4) yields:

$$R \geq 2D^2/\lambda \ . \qquad (2.5)$$

If antenna measurements are made at a range of $2D^2/\lambda$, there will be a significant departure of the nulls of the radiation pattern and the location and levels of the minor lobes from their infinite-range values. The amount of the deviation depends on the original side-lobe level and structure. D. R. Rhodes calculated that at a range of $2D^2/\lambda$ the first null of the pattern produced by a rectangular aperture with uniform illumination has a level of about -23 decibels instead of -∞ decibels. This deviation is caused only by phase-error effects. The incident-wave amplitude over the test aperture was assumed constant. The infinite range pattern in the above case has a $\frac{\sin x}{x}$ configuration with a first-lobe level of about -13 decibels.

Figure 2.3 is a graph showing the infinite range pattern of a circular aperture with a 30 decibel Taylor distribution and the patterns at separations of $2D^2/\lambda$ and $4D^2/\lambda$ as calculated by a Fourier Integral Computer. If an antenna such as this is adjusted for optimum focus at a range of $2D^2/\lambda$ or $4D^2/\lambda$ for example, the antenna will be slightly defocused for operation at extreme ranges. It is evident that, for extreme accuracy of the infinite-range side-lobe structure, measurements must be made at a range which is appreciably greater than $4D^2/\lambda$.

The above separation criterion is equally valid for the ground reflection mode of operation. In the case of the ground reflection range, R is the separation between the source-image array and the test aperture. 8, 9

[6]Rhodes, D. R. "On Minimum Range for Radiation Patterns," Proc. I. R. E. Vol. 42, No. 9, pp 1408-1410, September 1954.

[7]Hollis, J. S. et al, op cit.

[8]Hollis, J. S., et al, A Precision Ground-Reflection Antenna Boresight Test Range prepared for presentation at 14th Annual Symposium on USAF Antenna Research and Development, University of Illinois, October, 1964.

[9]Lyon, T. J., et al, Evaluation of the NASA-KSC-MILA RF Boresight Test Facility at X-Band and S-Band, Final Report, Contract No. NAS10-2103, May, 1900.
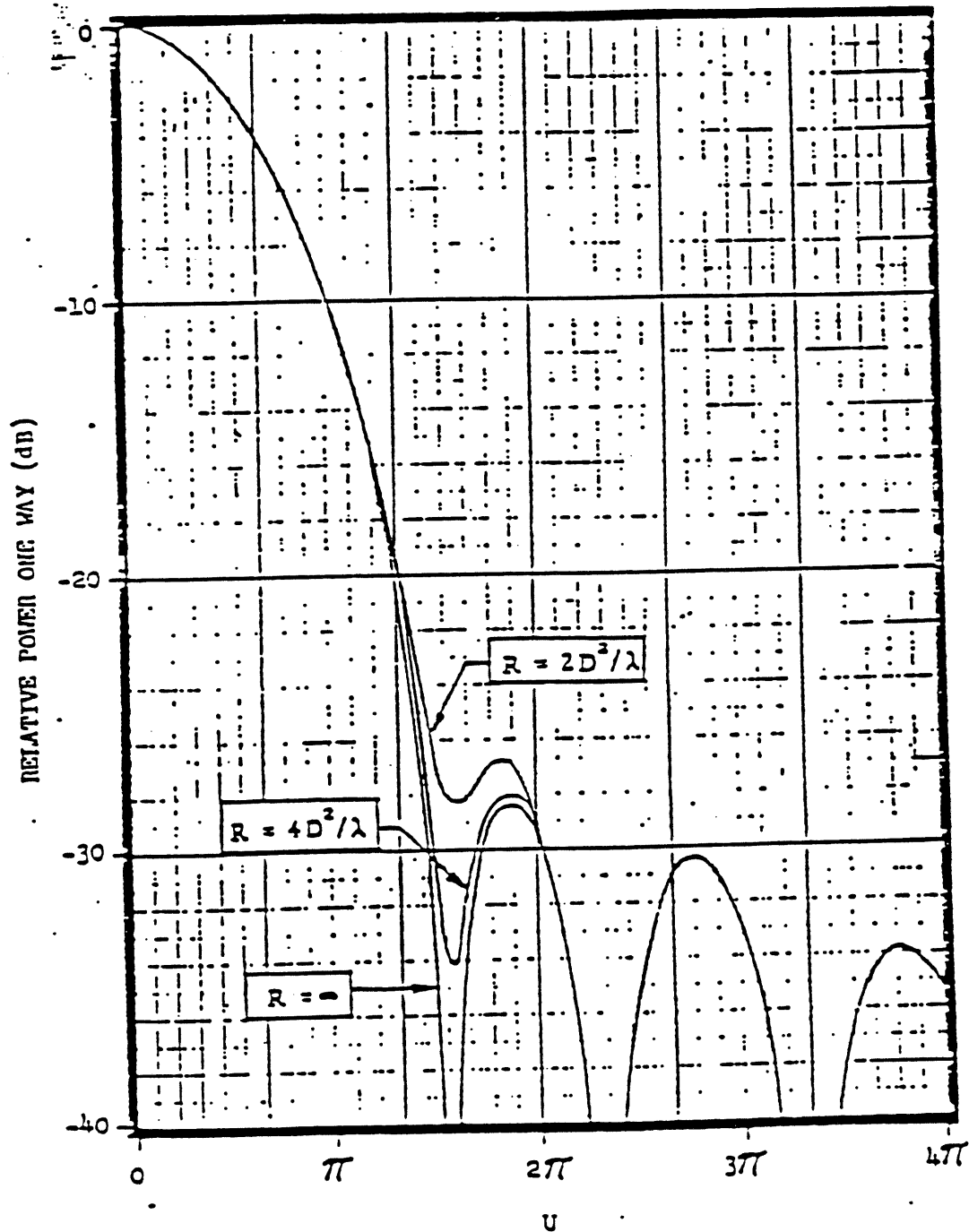
Figure 2.3 Calculated radiation patterns of a paraboloid with quadratic phase errors encountered in measuring at three ranges as indicated.

Actual calculated patterns for these various test separations are
shown in Figures 2.4 through 2.7. A 10-decibel cosine aperture
illumination function on transmitting was assumed for these patterns.
This illumination function is very similar to that of many
commonly used microwave antennas. The true pattern for the antenna
is shown in Figure 2.4 which represents illumination by a plane
wave of uniform amplitude. As the test separation is decreased, as
is shown sequentially in Figures 2.5 through 2.7, the nulls
fill in and the sidelobes are raised. This is accompanied by a lower
measured gain for the antenna. More will be said about this gain reduction
in the following section.

2.2.2 Amplitude Taper Over the Test Aperture

The effect of amplitude taper of the incident field over the test
aperture on receiving can be considered from the viewpoint of
reciprocity.[10] Variation of the amplitude of the field over the
aperture on receiving is analogous, within the accuracy of the
aperture field approach, to the modification of the aperture illumina-
tion by the primary feed on transmitting. For example, consider the
pattern of an antenna whose feed would produce an aperture illumination
$f(\theta,r)$ on transmitting, where (θ,r) indicates position in the
aperture. If illuminated on receiving by a source antenna which produces
over the test aperture an amplitude taper $g(\theta,r)$, the measured pattern
would be that of a transmitting antenna illuminated by a feed which
produces an illumination of $f(\theta,r)$ $g(\theta,r)$ over the aperture. If
$g(\theta,r)$ is constant in amplitude and phase over the aperture, the
measured pattern will be the same as the infinite-range pattern for the
illumination $f(\theta,r)$. The greater $g(\theta,r)$ deviates from constant, the
greater will be the deviation of the measured pattern from the infinite-
range pattern. The quantitative effect of nearly constant functions
$g(\theta,r)$ cannot be determined, however, without assumption of $f(\theta,r)$.

Figure 2.8 is a calculated infinite-range pattern of a circular aperture
with a 10-decibel cosine taper distribution as tested with a source antenna
which produces a circularly symmetric amplitude taper of 0.5 decibels at
the periphery.[11] The taper is assumed to have a $\frac{\sin x}{x}$ form which closely
approximates a large portion of the transmitted beam of most narrow-beam
antennas. The effects of amplitude taper on the calculated patterns are
not nearly as dramatic as the effects of phase taper caused by short range
lengths. The calculated patterns show nearly identical close-in sidelobes.
The reduction in gain is about 0.15 decibel for the 0.5 decibel taper.

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[10] Chastain, J. B., et al, op cit

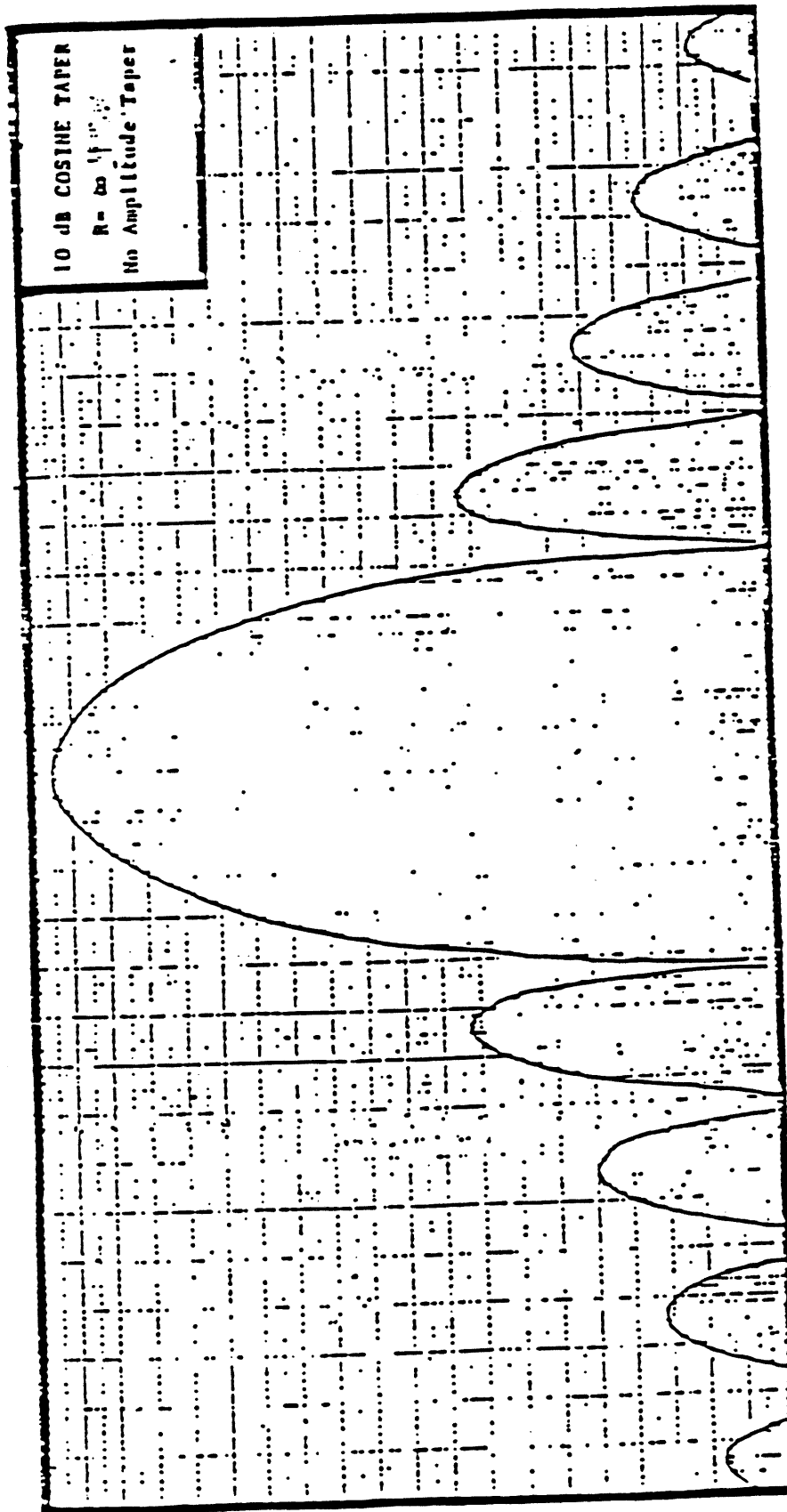[11] Hollis, J. S., et al, op cit

Figure 2.4 Calculated pattern of an antenna with a 10dB Cosine feed illumination function.
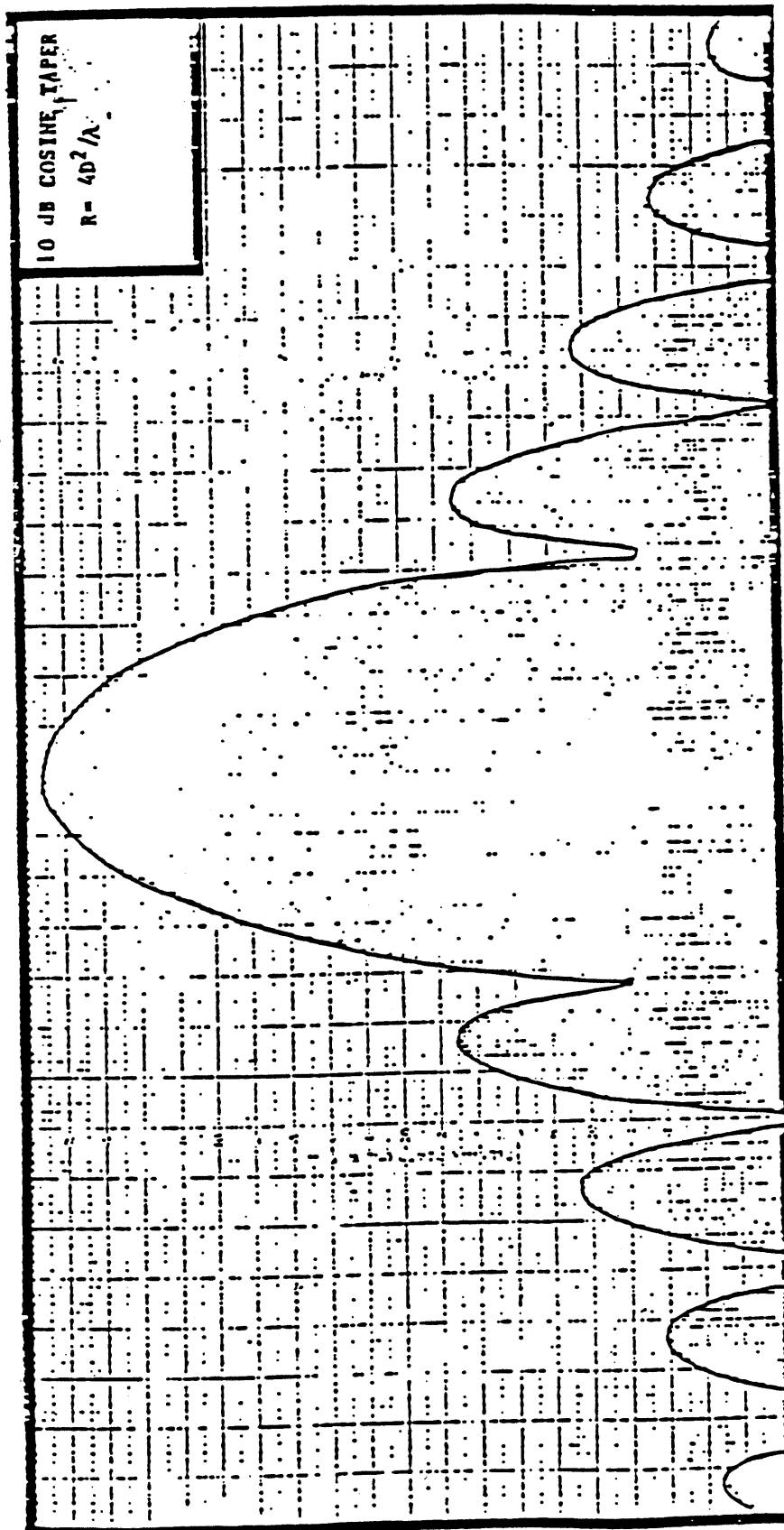
Figure 2.5   Calculated pattern of an antenna with a 10dB Cosine feed illumination function. A phase error is assumed which corresponds to a test separation of $4D^2/\lambda$.

Figure 2.6   Calculated pattern of an antenna with a 10 dB Cosine feed illumination function. A
phase error is assumed which corresponds to a test separation of $2D^2/\lambda$.
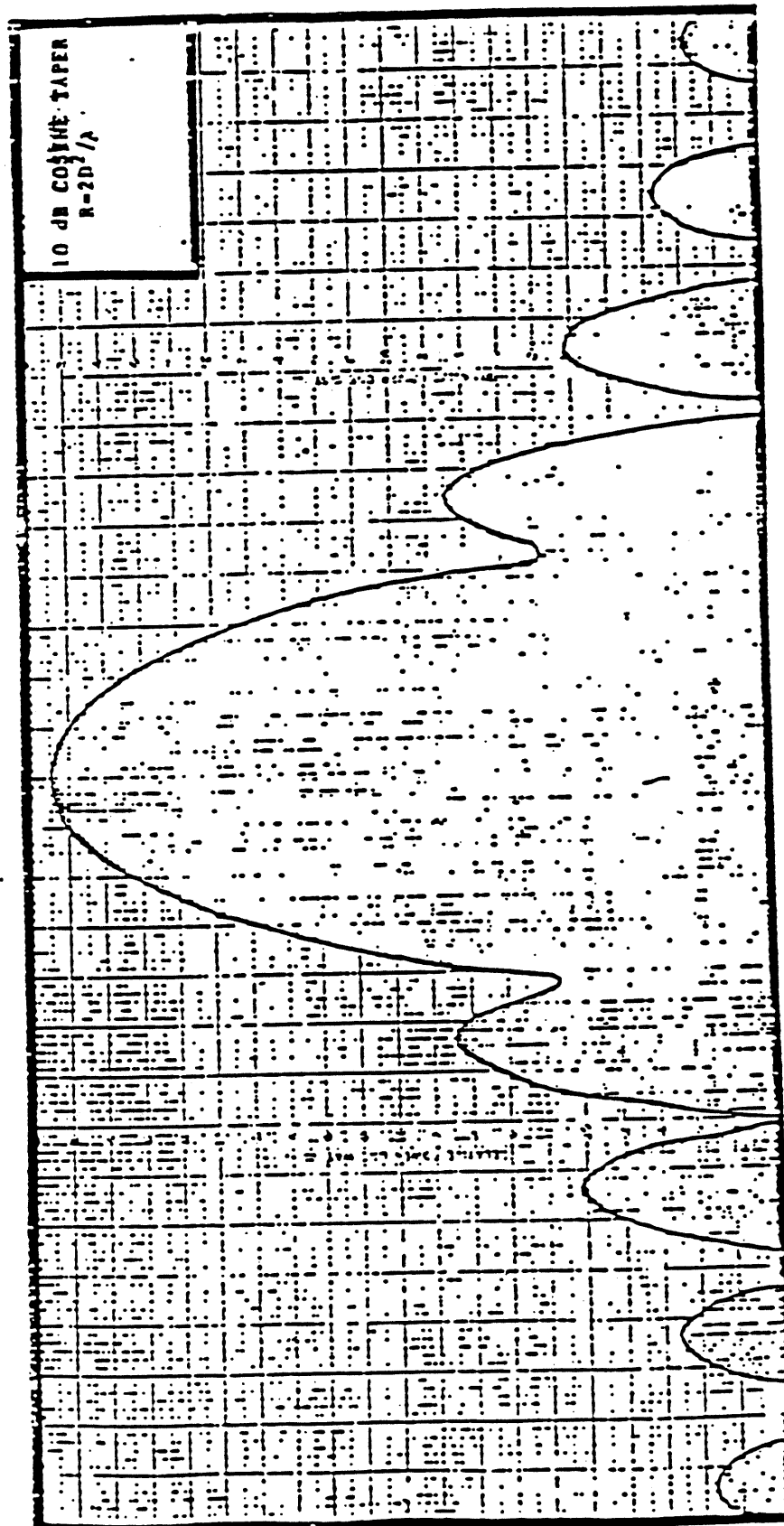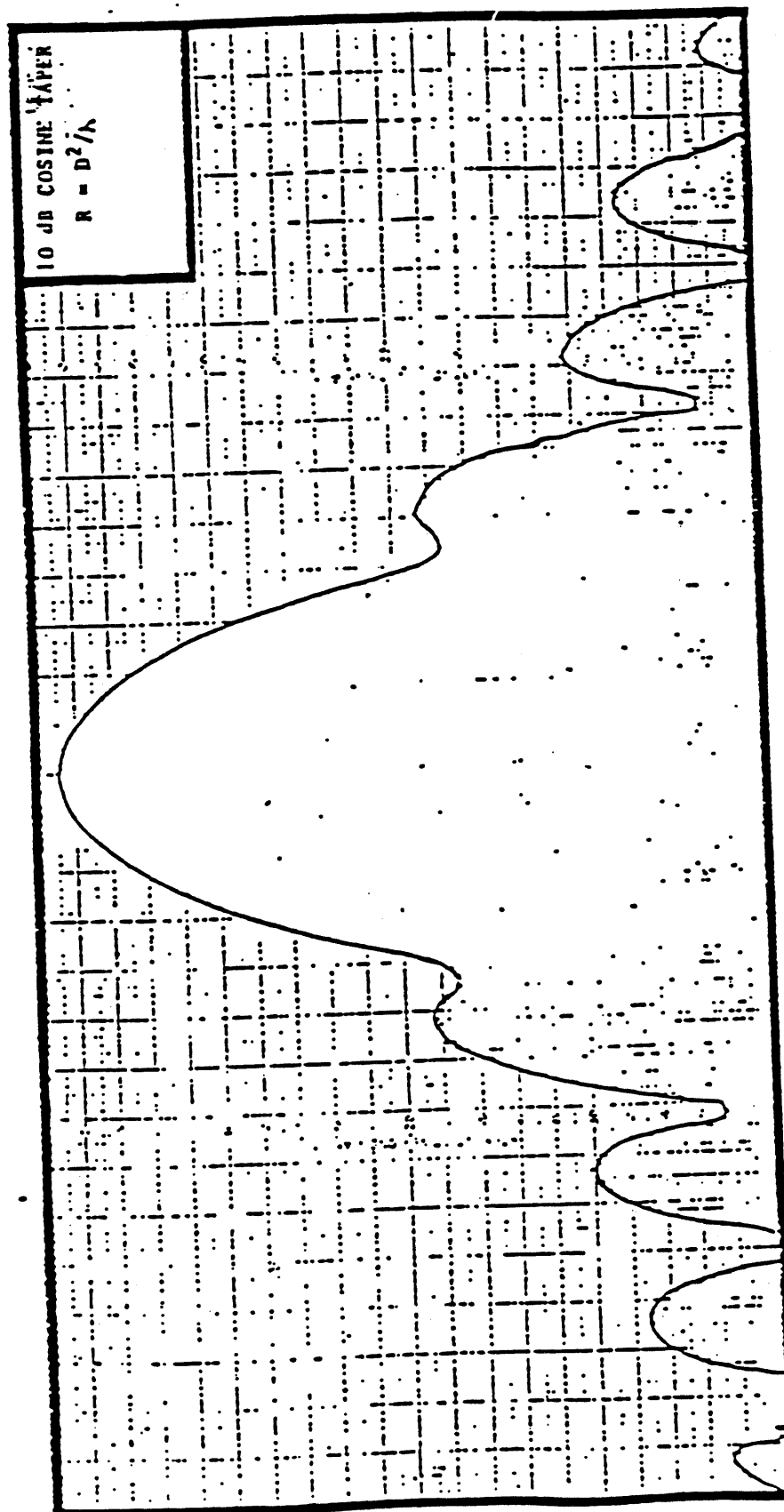
Figure 2.7   Calculated pattern of an antenna with a 10 dB Cosine-feed illumination function. A phase error is assumed which corresponds to a test separation of D^2/λ.
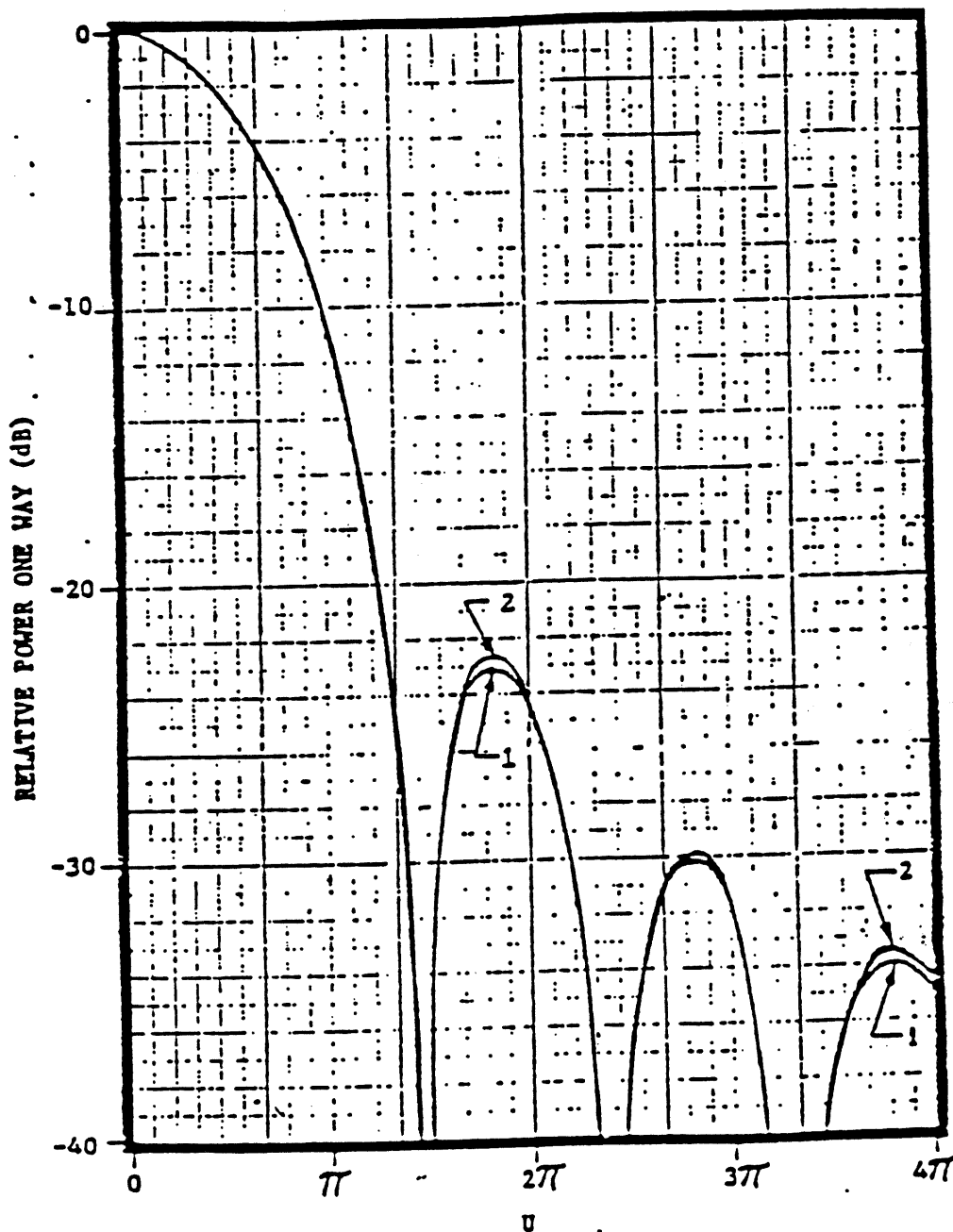
Figure 2.8 Calculated radiation patterns of a paraboloid with a 10 dB aperture illumination taper; (1) Measured with a 0.5 dB (Sin x)/x taper of the source antenna pattern, and (2) with no taper.

The decrease in measured gain caused by aperture taper is determined by the amount of taper and by the aperture illumination function of the antenna under test. For typical illumination functions, estimates of decrease in measured gain are 0.1 decibel for a 0.25 decibel taper and 0.04 decibel for a 0.1 decibel taper. A taper of less than approximately 0.01 decibel would be required to limit the decrease in gain to 0.01 decibel. A taper of 0.01 decibel would require a transmitting antenna 3-decibel beamwidth of approximately 16 times the width of the aperture under test..

Calculated values of these decreases in gain as functions of both phase and amplitude tapers are presented in Tables 2.1 through 2.4 for four different aperture illumination functions. It can be seen in these tables that the correction factors are of sufficient consistency with illumination function that reasonably accurate corrections can be made to measured gain using these tables alone.

A criterion of 0.25 decibel is commonly employed for the limit of the amplitude taper over the test aperture. Calculated patterns reveal little distortion to the expected pattern as a result of small amplitude tapers in the illuminating field. The calculated pattern for the 0.25 dB taper is essentially the same as the one for the uniform field. However, if a source antenna is employed which is calculated to produce a taper of the field over the test aperture, it is essential that the transmitting antenna be directed such that the peak of its beam is centered on the antenna under test to prevent excessive and asymmetrical illumination taper with a resultant increase in the measuring error.

It is important to note that error from symmetrical amplitude taper within the accepted criterion of 0.25 decibel does not produce a defocusing type of error but a small modification of the measured side-lobe levels and an error in measured gain. Figure 2.9 shows the effect of both a 0.25 decibel amplitude taper produced by the directivity of a transmit antenna and a 22.5° phase taper produced by a range length of $2D^2/\lambda$. The antenna is truly characterized by the pattern shown in Figure 2.4. A gain reduction of 0.154 decibels would accompany this pattern distortion.

TABLE 2.1

GAIN REDUCTION CORRECTIONS
CONSTANT ILLUMINATION FUNCTION

RANGE LENGTH (D^2/λ)	DECIBEL AMPLITUDE TAPER OF ILLUMINATING FIELD (SIN x)/x								
	0	.05	.1	.15	.2	.25	.5	.75	1.0
1	.224	.249	.276	.299	.325	.349	.469	.596	.720
2	.056	.080	.108	.130	.156	.181	.300	.427	.551
3	.025	.050	.076	.099	.125	.150	.269	.396	.520
4	.014	.139	.066	.089	.114	.139	.258	.386	.509
5	.009	.034	.061	.084	.109	.134	.253	.391	.504
6	.006	.031	.058	.081	.106	.131	.250	.378	.502
7	.005	.029	.056	.079	.105	.129	.249	.376	.500
8	.003	.028	.055	.078	.104	.128	.248	.375	.499
9	.003	.028	.054	.077	.103	.128	.247	.374	.498
10	-.002	.027	.054	.077	.103	.127	.246	.374	.498
	0	.025	.052	.075	.100	.125	.244	.372	.495

TABLE .2.2
GAIN REDUCTION CORRECTIONS
10 dB COSINE FUNCTION

RANGE LENGTH (D^2/λ)	DECIBEL AMPLITUDE TAPER OF ILLUMINATING FIELD (sin x)/x								
	0	.05	.1	.15	.2	.25	.5	.75	1.0
1	.206	.226	.240	.267	.200	.308	.405	.500	.609
2	.051	.072	.094	.112	.133	.154	.251	.355	.456
3	.023	.043	.065	.084	.105	.125	.223	.327	.428
4	.013	.033	.055	.074	.095	.115	.213	.317	.418
5	.008	.029	.051	.069	.090	.110	.208	.312	.413
6	.006	.026	.048	.067	.088	.108	.206	.310	.411
7	.004	.024	.047	.065	.086	.106	.204	.308	.409
8	.003	.024	.046	.064	.085	.106	.203	.307	.408
9	.003	.023	.044	.063	.084	.105	.202	.307	.407
10	.002	.020	.042	.061	.082	.102	.200	.306	.405

TABLE 2.3
GAIN REDUCTION CORRECTIONS
10 dB $(1-\rho^2)$ ILLUMINATION FUNCTION

RANGE LENGTH (D^2/λ)	DECIBEL AMPLITUDE TAPER OF ILLUMINATING FIELD (SIN x)/x								
	0	.05	.1	.15	.2	.25	.5	.75	1.0
1	.204	.224	.246	.265	.206	.307	.404	.509	.610
2	.051	.071	.093	.112	.134	.154	.252	.357	.459
3	.023	.043	.065	.084	.105	.126	.224	.329	.431
4	.127	.033	.055	.074	.096	.116	.214	.319	.421
5	.008	.029	.051	.070	.091	.111	.210	.315	.417
6	.006	.026	.048	.067	.089	.109	.207	.312	.414
7	.004	.025	.047	.066	.087	.107	.206	.311	.413
8	.003	.024	.046	.065	.086	.106	.205	.310	.412
9	.003	.023	.045	.064	.085	.105	.204	.309	.411
10	.002	.020	.043	.062	.083	.103	.202	.307	.409

TABLE 2.4
GAIN REDUCTION CORRECTIONS
15 dB $(1-\rho^2)$ ILLUMINATION FUNCTION

| RANGE LENGTH (D^2/λ)	DECIBEL AMPLITUDE TAPER OF ILLUMINATIN FIELD (SIN x)/x								
	0	.05	.1	.15	.2	.25	.5	.75	1.0
1	.100	.206	.227	.244	.263	.282	.373	.470	.564
2	.047	.096	.086	.104	.124	.142	.234	.331	.425
3	.021	.040	.060	.070	.098	.116	.200	.305	.399
4	.012	.031	.051	.069	.089	.107	.199	.296	.391
5	.007	.026	.047	.065	.084	.103	.195	.292	.386
6	.005	.024	.045	.062	.082	.101	.192	.290	.304
7	.004	.023	.034	.061	.081	.100	.191	.288	.383
8	.003	.022	.042	.060	.080	.099	.190	.287	.382
9	.002	.021	.042	.060	.079	.098	.189	.207	.301
10	.002	.021	.041	.059	.079	.098	.189	.286	.301
	0	.019	.040	.051	.077	.096	.187	.205	.379
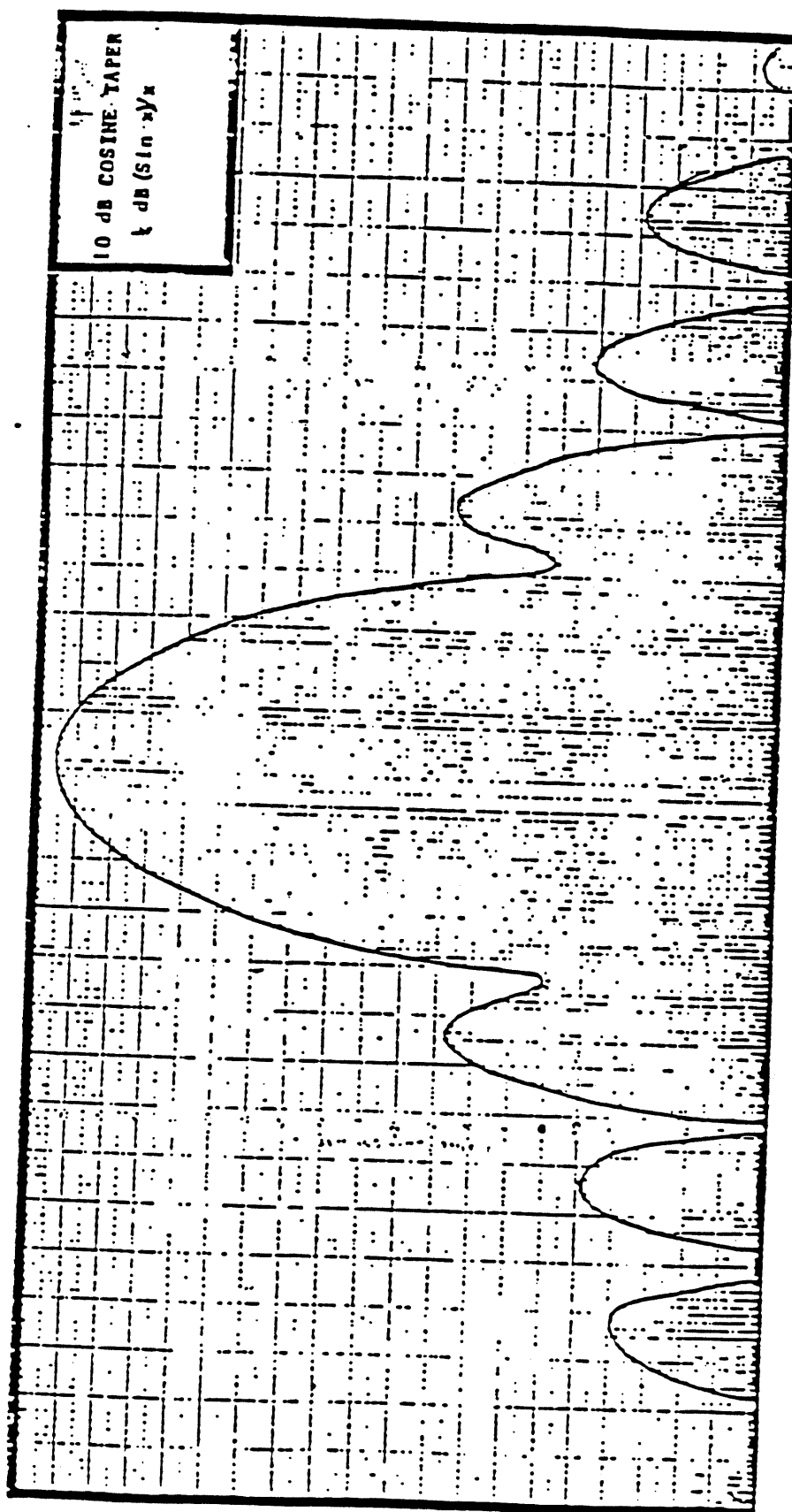
Figure 2.9 Calculated pattern of an antenna with a 10 dB Cosine feed illumination function. A phase taper corresponding to a test separation of 2D²/λ and a 0.25 dB amplitude taper of the illuminating field characterized by a (sin x)/x distribution are assumed.

The geometry of the elevated range is shown in Figure 2.10. Neglecting reflected energy from the range surface which will be discussed later, the amplitude taper across the test antenna is controlled by the beamwidth of the transmit antenna. The angle α subtended by the antenna under test, denoted by D in the figure is given by:

$$\alpha = 2 \tan^{-1} (D/2R_0) \doteq D/R_0 \qquad (2.6)$$

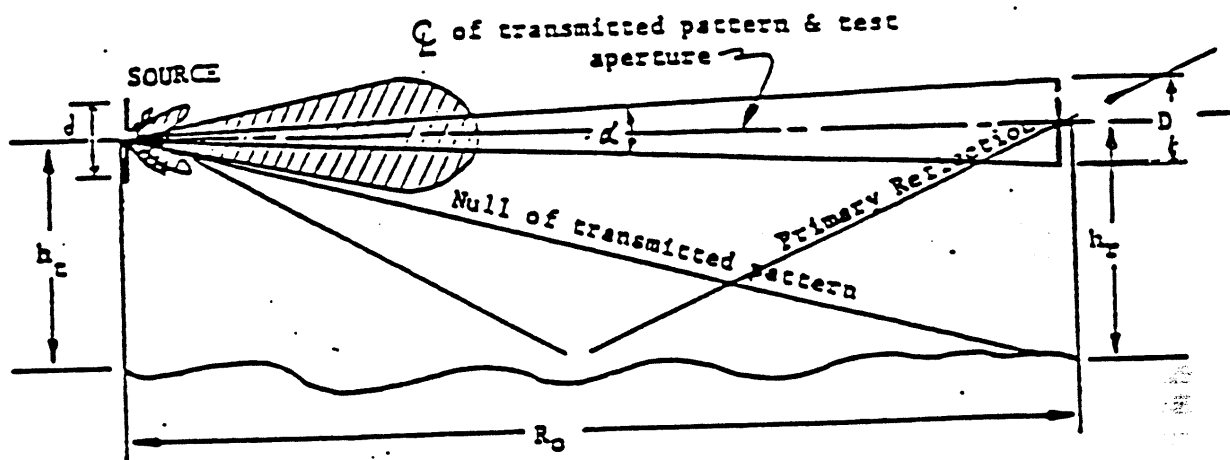since $R_0 \gg D$. The approximate 1/4 dB beamwidth θ (.25) of typical

Figure 2.10 Elevated Antenna range geometry.

paraboloidal antennas commonly used for source antennas in the elevated mode is given by:

$$\theta (.25) \doteq 0.37\lambda/d, \qquad (2.7)$$

where d is the diameter of the source antenna and λ is the wavelength. It is readily seen that restricting the amplitude taper on the test antenna to a maximum of 0.25 dB is analogous to restricting the maximum diameter

of the source antenna. Therefore:

$$0.37\lambda/d \geq D/R_o \qquad (2.8)$$

or

$$d_{max} = 0.37\lambda R_o/D. \qquad (2.9)$$

2.3 Extraneous Energy

The primary source of extraneous energy on an antenna range is reflections. A source of reflections that is common to all antenna ranges is the range surface. In the elevated mode of operation, the reflections from the vicinity of the range surface are minimized by clearing the vicinity of the range centerline of all obstacles such as trees, shrubs, etc.; selecting a source antenna of high directivity so as to allow only sidelobe energy to illuminate the range surface; and screening the surface from sidelobe energy by strategically placed conducting screens.

Refer to the geometry of Figure 2.10. Assume that the maximum amplitude taper of 0.25 dB exists across the aperture. The 0.25 dB beamwidth and main beam null separation for typical sin(x)/x microwave antenna patterns are related by

$$\theta(NULL) \doteq 8\theta(.25) \qquad (2.10)$$

If the main lobe energy is restricted from the range surface, then the lower limit for the null of the transmitted pattern is the base of the receiver tower and:

$$\theta(NULL) \leq 2\tan^{-1}(h_T/R_o) \doteq 2h_T/R_o \qquad (2.11)$$

since $R_o \gg h_T$. Combining this with equations (2.8), (2.9), and (2.10)

$$h_T \gtrsim 4\ D \qquad (2.12)$$

A practical design criterion for elevated test ranges is that the receive tower is 4.5 to 5 times the maximum dimension of the test aperture.

When R_o and h_T have been selected, the illumination criterion of equation (2.11) can be used to specify a minimum diameter of the source antenna.

$$\theta(NULL) \doteq 8\theta(.25) \doteq 8(.37\lambda/d) \leq 2h_T/R_o. \qquad (2.13)$$

This requires that:

$$d_{min} = 1.5\ \lambda R_o/h_T. \qquad (2.14)$$

Therefore, a minimum source antenna diameter has been established due to the condition that only side-lobe energy be allowed to illuminate the ground. A maximum diameter was established to guarantee an acceptable amplitude taper across the test antenna. The restrictions on the size of the source antenna become:

$$1.5 \lambda R_0/h_r \leq d \leq 0.37 \lambda R_0/D. \qquad (2.15)$$

Many tests require suppression of range-surface reflections beyond that afforded by practical tower heights and source antenna sizes. Compliance with the criteria of equations (2.12) and (2.14) would probably result in an extraneous signal suppression of the order of -25 decibels relative to the direct-path signal level. The desired suppression can be calculated from the specified accuracy requirements by use of the expression

$$r = 20 \log (1 - 10^{-a/20}) + G_D - G_R \qquad (2.16)$$

where

r is the ratio of reflected to direct-path signal levels in decibels ($r = 20 \log E_R/E_D$),

a is the desired measurement accuracy in decibels,

G_D is the decibel gain of the test pattern in the direction of the direct-path signal, and

G_R is the decibel gain of the test pattern in the direction of the reflected signal.

It has been found that even over a very smooth surface, primary reflections can be additionally suppressed to levels less than -35 decibels through the use of strategically placed diffraction fences. Design values for the dimensions and locations of such fences can be calculated using Fresnel zone theory*, while final adjustments to the fence installations must be accomplished experimentally by means such as probe data of the field over the test aperture. While general criteria have not been developed which apply to all elevated range configurations, experience has shown that fences which screen approximately the first 20 Fresnel zones on the mean range surface will provide from -35 decibels to -40 decibels of suppression of range surface reflections when the terrain is nominally regular in cross-section and the previously discussed criteria are satisfied. It is necessary to arrange these fences so that little or no blockage of the main lobe of the transmitter pattern is caused by the fences. This precaution ensures that the residual variations in the field over the test aperture due to diffraction effects at the fences will represent a reasonable compromise with the level of reflected signal suppression.

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*Although Fresnel zones are rigorously defined on the basis of point source radiators, for practical antenna range geometries Fresnel zones for a point in the receiving aperture can be defined by regarding the transmitting antenna to be a point source located at the center-of-phase of its aperture.

A full development of Fresnel zone theory will not be presented here. The pertinent parameters of the Fresnal zones over a mean planar surface are the center, length, and width of the ellipse which describe the outer bound of a particular zone. These parameters can be calculated from the range geometry and the frequency of operation.*

In addition to providing line-of-sight clearance, low-level range surface illumination, and range surface screening via diffraction fences, the facility design should also ensure the clearance of all major extraneous reflecting or diffracting obstacles over the region within about 1.5 to 2 times the azimuthal main-lobe width of the transmitted pattern. Grading along the range boundaries can be performed to remove regions of possible wide-angle specular reflection into the test aperture.

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* See, for example, Holis, J. S., et al, Microwave Antenna Measurements, Section 14.2.4.

2.3.1 Effects of Reflected Energy

Consider the case of a direct-path plane wave of amplitude E_d which is normally incident on the test aperture[12] as shown in Figure 2.11(a). Let an extraneous plane wave of amplitude E_r enter the aperture at an angle θ from the normal. At any given time, t, the phase of the direct wave is constant across the aperture and the direct-path field magnitude may be expressed in phasor notation as

$$E_d{}^* = E_d e^{j(\delta + \omega t)} \qquad (4.1)$$

where the asterisk denotes a complex quantity.

The phase of the postulated extraneous plane wave will vary across the aperture, so that the extraneous field magnitude is given by

$$E_r{}^* = E_r e^{j(2\pi x \sin\theta/\lambda + \delta' + \omega t)} \qquad (4.2)$$

In (4.1) and (4.2), δ and δ' are constants, λ is the wavelength, and x is distance measured across the aperture parallel to the plane containing the directions of propagation of $E_d{}^*$ and $E_r{}^*$. The magnitude of the total field in the aperture is that given by[13]

---

[12]The discussion here assumes a separation, R, between source and receiving antennas equal to or greater than $2D^2/\lambda$, where D is the maximum dimension of the receiving aperture. It is further assumed that the ratio D/R is small in comparison with the half-power beamwidth of the source antenna's pattern, so that the plane wave approximations are meaningful.

[13]This simplified example assumes that the polarizations of the reflected and direct-path waves are identical. While this is not strictly true, often the reflected wave will contain a large component with polarization identical to that of the direct-path wave.
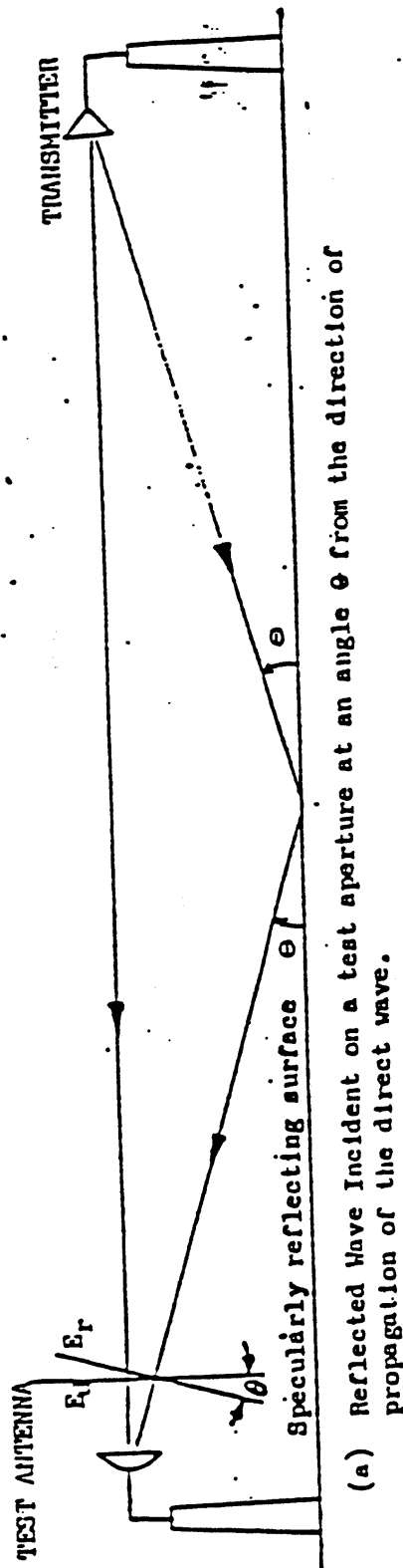
(a) Reflected Wave incident on a test aperture at an angle θ from the direction of propagation of the direct wave.
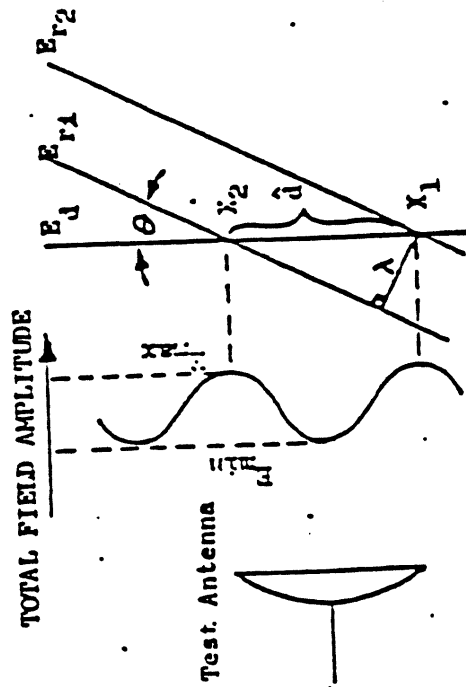
(b) Details of wave interference.

(c) Equivalent Phasor Representation.

Figure 2.11 Simplified sketch illustrating total aperture field variation caused by a single specularly reflected wave.

$$E_t{}^* = E_d{}^* + E_r{}^* = \left[E_d e^{j\delta} + E_r e^{j(2\pi x \sin\theta/\lambda + \delta')} \right] e^{j\omega t} \quad (4.3)$$

Equation (4.3) describes a field with a sinusoidal variation in one dimension as sketched in Figure 2.11(b). In this figure, E_{r1} and E_{r2} represent two successive wavefronts of the reflected wave separated by λ, and E_d is a wavefront of the direct wave of identical phase. At points x_1 and x_2, the resultant amplitude is

$$E_{max} = E_d + E_r \quad (4.4)$$

Halfway between these two points the waves are in phase opposition, and the resultant amplitude is

$$E_{min} = E_d - E_r \quad (4.5)$$

The maximum amplitude variation within the aperture is thus given by

$$E = E_{max} - E_{min} = 2 E_r \quad (4.6)$$

Figure 2.12 is a graph of the magnitude of the resultant field amplitude ripple as a function of the ratio E_r/E_d.

The angle θ can be determined by

$$\theta = \sin^{-1}(\lambda/\hat{d}) \quad (4.7)$$

where $\hat{d}$ is seen in Figure 2.11(b) to be the spatial period of the resulting interference pattern across the aperture.

The field in the aperture may also be represented as the sum of the two phasors, $E_d{}^*$ and $E_r{}^*$, as illustrated in Figure A2.11(c), where $E_r{}^*$ rotates relative to $E_d{}^*$. The phase of the field across the aperture will vary as the phase of the resultant of the direct-path and reflected phasors. The maximum phase variation for this plane wave case is then

$$\Delta\varphi = 2 \sin^{-1} (E_r/E_d), \quad (4.8)$$

where E_r is less than E_d.

The preceding example, although representing an idealized reflection, demonstrates the manner in which extraneous signals distort an otherwise planar wavefront. In a practical test situation, neither the direct nor the extraneous waves would be strictly planar, and there would be extraneous signal sources which could contribute to distortion of the incident field. For elevated ranges, however, for which the region around the range line-of-sight is relatively clear of reflecting objects, the primary source of extraneous signals is the range surface, and the mathematical model developed above is a useful approximation to the physical situation.
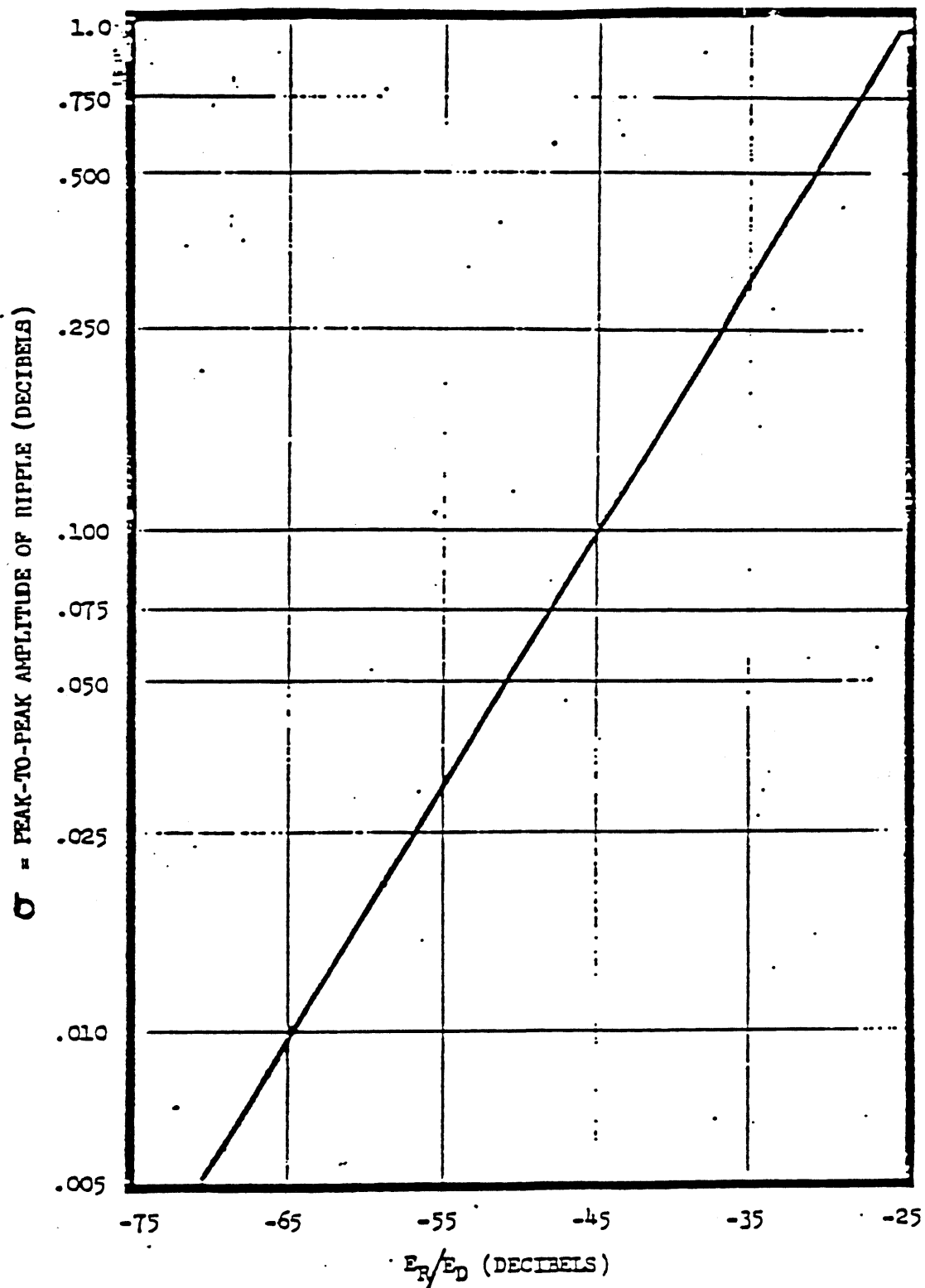
Figure 2.12 Magnitude of the maximum field perturbation as a function of the relative magnitude of the reflected signal.

2.3.2 Range Fences [14]

Energy which is incident on the range surface is reradiated in all
directions. That energy which is reflected into the test aperture is a
summation of wavelets reradiated from every point on the surface. If
the surface is smooth in terms of the wavelength of the radiation, the
energy striking the surface will be reradiated with a major lobe in
the specular direction (angle of incidence equal to the angle of reflection)
in accordance with Fermat's principle of stationary phase[15]. When the
wavelength is sufficiently short and the range separation sufficiently
long, reflection from a smooth range surface approaches the geometrical
optics approximation in which all energy is reflected in the specular
direction.

Reflection from a smooth surface can be analyzed by defining Fresnel zones
on the surface similar to those defined in physical optics[16]. If the sur-
face is planar, as well as smooth, the Fresnel zones produced by a point
source radiator will be defined by a family of expanding ellipses[17].
Conventionally the zones are identified by numbering them consecutively,
beginning with the inner zone. The specular point falls within the first
Fresnel zone and, for typical elevated ranges, is near the geometrical
center of the first zone. Although reflected energy from the entire

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[14]For further discussion of this topic see:
  T. J. Lyon, et al, "Evaluation of the NASA-KSC-MILA RF
  Boresight Test Facility at X-Band and S-Band," FINAL REPORT
  Contract No. NAS10-2103, Scientific-Atlanta, Inc., N-67-13025.
  J. S. Hollis, et al, "Investigation of Precision Antenna Pattern
  Recording and Display Techniques, Phase II," FINAL REPORT,
  Contract No. AF30(602)-3425, Scientific-Atlanta, Inc., AD630214.

[15]S. Silver, Microwave Antenna Theory and Design, Radiation Laboratory
Series, Vol. 12, McGraw-Hill Book Co., pp. 119-128, 1950.

[16]See, for example, D. E. Kerr, Propagation of Short Radio Waves, Radiation
Laboratory Series, Vol. 13, McGraw-Hill, pp. 411-418, 1951.

[17]It should be noted that Fresnel zones, as used here, are defined in terms
of isotropic radiators and receivers. Such zones differ considerably from
the half-period zones which could be defined in terms of the actual directive
source and test antennas. Excellent results have been achieved on the basis
of isotropic antenna analysis, however, and further complication of the
mathematics appears to be unnecessary in most cases.

range surface contributes to the extraneous signal level at the test aperture, the level can be reduced considerably by blocking reflected energy from the first several Fresnel zones. Reduction of the relative extraneous signal level at the test aperture by approximately 10 to 20 decibels is achievable by blocking reflections from at least the first 20 zones, for typical elevated antenna range problems[18]. This blockage is easily achieved through the use of conducting fences placed on the range surface over the central Fresnel zones[19].

In choosing a fence configuration for an elevated range, consideration must be given to the problem of interference due to diffraction over the fence edges. The energy which reaches the test aperture is the summation of contributions from all points on a spherical wavefront encompassing the source, as described in Huygen's principle[20, 21, 22]. Thus, blockage of any portion of the transmitted wavefront results, through the process of diffraction, in a perturbation of the energy incident on the test aperture. The nature of the diffraction disturbance can be illustrated with the simplified example of diffraction over an infinite, straight, absorbing edge which is placed between a radiator and a plane AB, as shown in Figure 2.13. It is desired to know the magnitude of the field at a point P, which lies in the plane AB. The absorbing half-plane blocks a portion of the wavefront; the field at P is determined by applying Huygen's principle to sum the contributions at P from the remainder of the wavefront. The normalized field at P can be approximated by[23]

$$\frac{E}{E_o} = \left| \frac{1}{\sqrt{2}} \int_u e^{-j(\pi v^2/2)} \, dv \right| , \qquad (4.9)$$

$$v = u \left[\frac{2(d_1 + d_2)}{\lambda d_1 d_2} \right]^{\frac{1}{2}} \qquad (4.10)$$

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[18]Lyon, et al, op cit.

[19]Ideally, absorbing fences are preferred to eliminate the possibility of reflections from the fences resulting in measurement interference; if the fences are properly designed, however, interference from this source is often negligible.

[20]E. C. Jordan, Electromagnetic Waves and Radiating Systems, Prentice-Hall PP. 572-577, 1950.

[21]Bruno Rossi, Optics, Addison-Wesley, Chapter 4, 1957.

[22]R. S. Longhurst, Geometrical and Physical Optics, Chapter 10, 1957.

[23]E. C. Jordan, op cit.

and where E_0 is the field which would result from the unobstructed wave, u is the arc length measured along the wavefront from the line TP, v_0 corresponds to the point of the wavefront which inter-sects the top of the obstruction, d_1 is the radius of the wavefront, and d_2 is the distance from the wavefront to P.
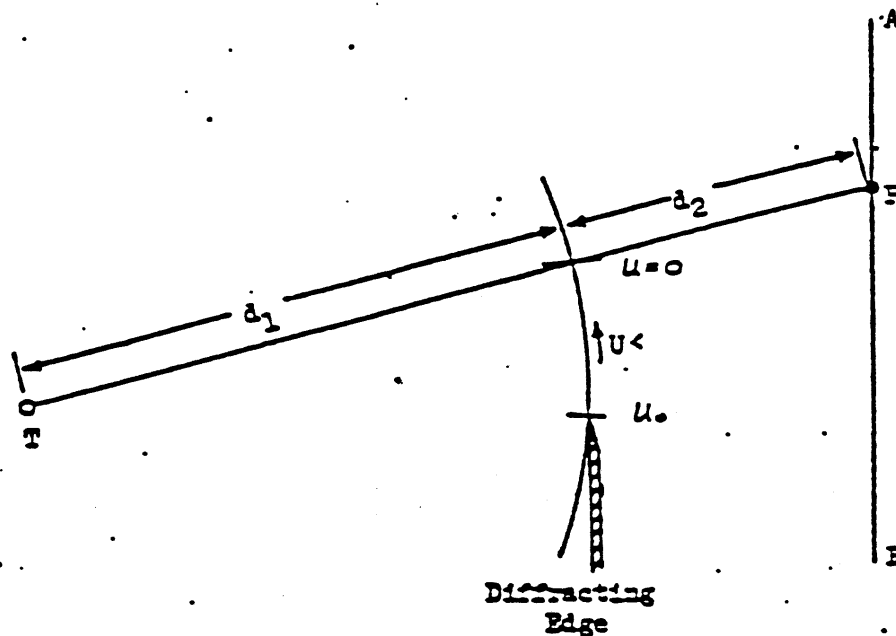
Figure 2.13 Edge Diffraction Geometry.

A plot of equation (4.9) is reproduced in Figure 2.14. Positive values of v_0 correspond to field points in the shadow region; negative values correspond to field points in the region of direct illumination. The resultant field magnitude in the direct illumination region varies in an oscillatory manner with the location of the observation point. This disturbance is essentially equivalent to that which would be caused by a coherent cylindrical wavefront emanating from the diffracting edge which system-atically interferes with the spherical wavefront of the unobstructed signal.

The foregoing example is obviously idealized. Clearly, an infinite, perfectly-absorbing half-plane is not physically realizable; it has been shown, however, that diffraction patterns for finite, reflecting edges

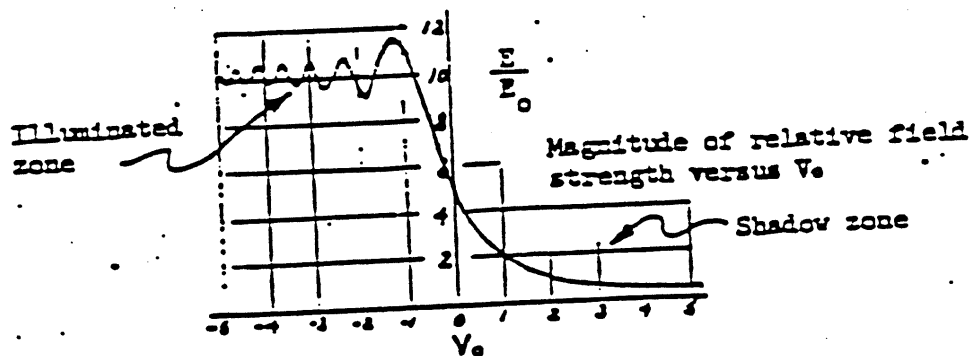are similar to the theoretical pattern of Figure 2.14.[24, 25].

Figure 2.14   Field amplitude due to diffraction at an edge.

Diffraction disturbances can be reduced by increasing the clearance of the range line-of-sight above the fences and by utilizing the directivity of the source antenna to minimize the energy blocked by the fences. A desirable design goal is to provide for sufficient clearance over each fence to allow passage of the entire principal lobe of the radiated energy distribution. Further reduction can be achieved, if required, by shaping the tops of the fences (with serrations, for example) to destroy the phase coherence of the diffracted energy.

[24]H. Martinides, "The Screening Effect of Obstacles With a Straight Edge," Goddard Space Flight Center, N65-33504-04, 1965, p.5.

[25]T. J. Lyon, et al, op cit.

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Altus AFB	NAF El Centro
Barksdale AFB	NALF San Clemente
Beale AFB	NAS Brunswick
Buckley ANG	NAS Cecil Field
Cannon AFB	NAS Corpus Christi
Cheyenne ANG	NAS Dallas
Columbus AFB	NAS Fallon*
Davis-Monthan AFB	NAS Jacksonville
Dobbins AFB	NAS Key West
Dover AFB	NAS Kingsville
Dyess AFB	NAS Lemoore
Edwards AFB	NAS Meridian
Eglin AFB	NAS New Orleans
Eilsen AFB	NAS Norfolk
Ellsworth AFB	NAS North Island
Elmendorf AFB	NAS Oceana
FACSFAC Jacksonville	NAS Patuxent River
FACSFAC Pearl Harbor*	NAS Pensacola*
FACSFAC Roosevelt Roads	NAS Point Mugu
FACSFAC San Diego	NAS South Weymouth
FACSFAC VACAPES	NAS Whidbey Island
Fairchild AFB	NAS Whiting Field
Grand Forks AFB	NAS Willow Grove
Grissom ARB	NATTC Memphis
Hill AFB	NAVSTA Mayport
Hill ANG	NAVSTA Roosevelt Roads
Holloman AFB	NAVWPNCEN China Lake
Homestead ARS	NOLF Imperial Beach
Keesler AFB	Offutt AFB
Kelly AFB	Patrick AFB
Langley AFB	Pease ANG
Laughlin AFB	Pope AFB
Little Rock AFB	Randolph AFB
Luke AFB	Robins AFB
MacDill AFB	Scott AFB
March AFB	Selfridge ANG
Maxwell AFB	Seymour Johnson AFB
MCAS Beaufort	Shaw AFB
MCAS Camp Pendleton	Sheppard AFB
MCAS Cherry Point	Tinker AFB
MCAS Kaneohe Bay*	Travis AFB
MCAS Miramar	Tyndall AFB
MCAS New River**	USCG Elizabeth City
MCAS Yuma	Vance AFB
McChord AFB	Vandenberg AFB
McConnel AFB	Volk Field
McGuire A B	Westover ARB
Minot AFB	Whiteman AFB
Moody AFB	Wright-Patterson AFB
Mountain Home AFB	WSMR AFB